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SPECIAL MARINE ISSUE

Volume 6 ■ Number 1 ■ Summer 1996

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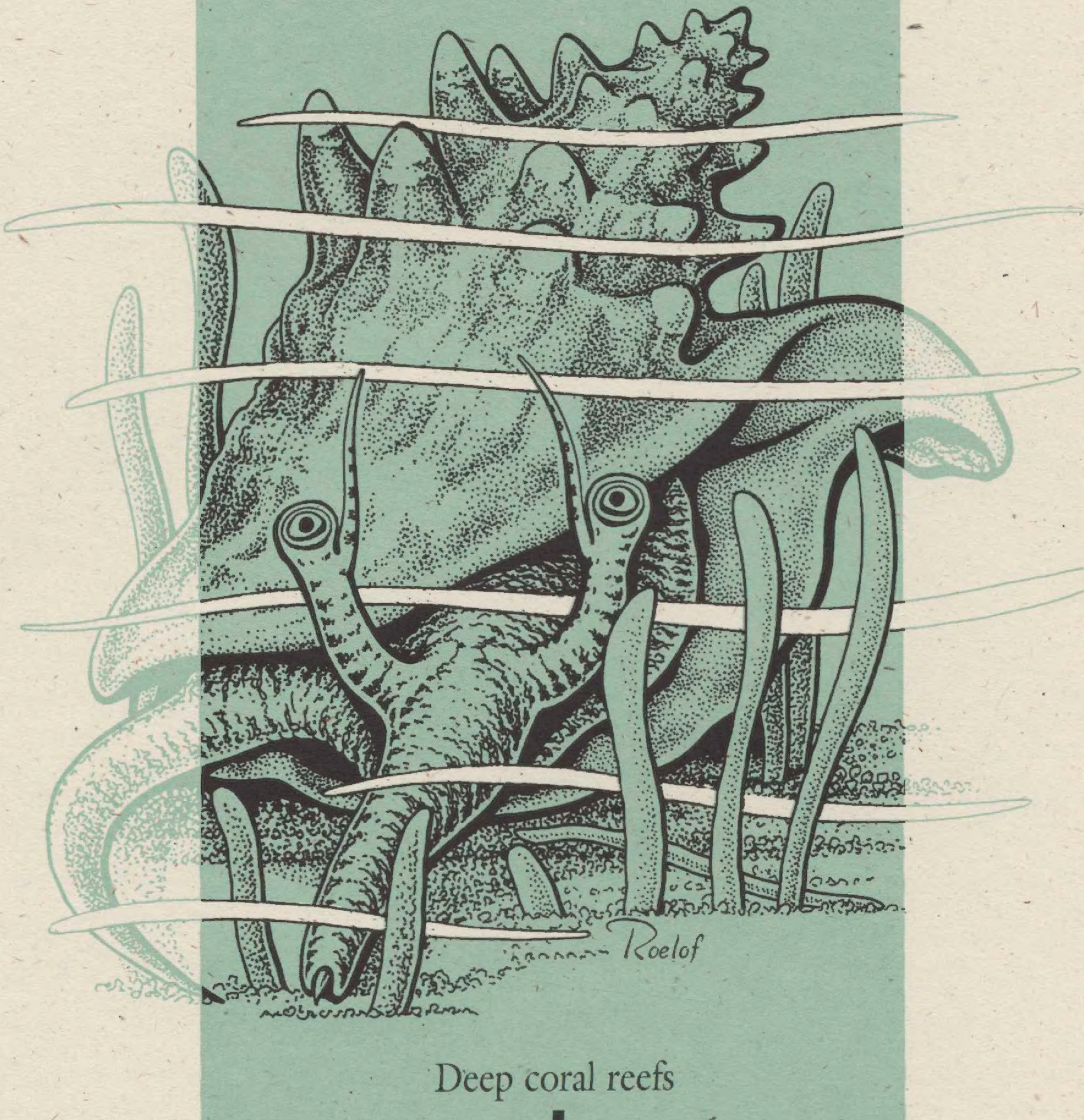
Global biodiversity

An International Forum on the Variety of Life on Earth...
research, conservation and wise use



Deep coral reefs
■
Hydrothermal vents
■
Cuba, the Caribbean, and Conservation

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Editor's Notebook

THE EARTH'S BIGGEST ECOSYSTEM IS AT RISK AND UNPROTECTED

The Earth's biggest ecosystem is faced with a number of anthropogenic stresses, and has virtually no protected areas. That ecosystem is not on land. It is the ocean waters lying beyond the continental shelf, covering 60% of the planet and averaging 4 kilometres deep — the oceanic realm.

The ocean realm is exposed to a number of human stresses and threats. Starting at the thin surface layer or neuston, species are stressed by increased ultraviolet (UV) radiation resulting from the thinning of the ozone layer. This affects those phytoplankton, the tiny plants that are the basis of the food chain, living close to the surface. Since UV rays damage tissue and genetic material, small, semi-transparent organisms that live at the sea surface are threatened. Many marine organisms, including those of the deep sea, have surface-living egg and or larval stages that make them sensitive to UV radiation, too.

In addition the surface layer of the ocean is subject to widespread oil pollution. This layer interferes with the exchange of gases and energy between the atmosphere and sea surface. Additionally crude oil contains components toxic to certain organisms. A film of oil can prevent larval fishes from taking their first gulp of air, needed to "seed" their swim bladder with its bubble of air.

Affecting the whole water column of the ocean are two factors, changes in temperature and toxic substances. The first, global warming, is already occurring. The Arctic ice pack is shrinking and coral reefs are undergoing bleaching as water temperatures exceed normal warm-season conditions for prolonged periods. If warming continues we may expect to see more stable warm layers at the surface in the polar regions. This means that cold saline water will no longer sink in the Arctic and Antarctic oceans to the ocean floor. The deep sea around the world is supplied by this saline cold water at about 4°C. Will the deep sea become less oxygenated and warmer as a result? Will this affect the deep-sea biota?

The second factor sees toxic and radioactive substances slowly permeating the ocean realm from coastal, and atmospheric input and from accidents and offshore disposal practices. So despite its distance from most human activities, the ocean realm is being significantly modified.

At present there are a few continental shelf protected areas, like the Great Barrier Reef park, that extend just into the edge of the ocean realm. But there are no park-like areas significantly beyond the continental margins that legally protect all the biota. This means that over half the globe has no protected areas. If we are to transmit the planet's largest ecosystem in natural condition to future generations, we must make conservation of environments beyond the continental shelves a higher priority. We must use the International Biodiversity Convention to bring law and order to this sophisticated and complex world.

Don E. McAllister

Don E. McAllister
Editor

The goals of Global biodiversity are to:

- *Publish articles, views, and news on biodiversity*
- *Bridge the gaps between professional disciplines & the public*
- *Communicate vital information to help humankind make decisions on the fate of the Earth's life*
- *Express views on the needs & value of biodiversity research*
- *Provide an international forum for discussing issues on biodiversity*
- *Enhance awareness of the role of biosystematic research & museum collections in conservation & ecologically sustainable use of biodiversity*
- *Discuss methods and philosophy of biodiversity conservation*
- *Review books and major articles on biodiversity*

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Global biodiversity

Volume 6, Number 1, Summer 1996

The Queen Conch, *Strombus gigas,* was once so abundant it provided the Florida Keys island chain with its nickname "The Conch Republic." It is now severely depleted. For more information on "vanishing biodiversity" and how to protect it, see page 8.

Editor:
DON E. McALLISTER, Ph.D.

Associate Editors:
ALEJANDRO ARGUMEDO, Cultural Survival Canada
PAUL CHABEDA, United Nations Environment Program
MAXIMO T. KALAW, JR., Haribon Foundation, Manila
ELIZABETH MAY, LL.D., Sierra Club of Canada
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IAN SMITH, Ph.D., Agriculture and Agri-Food Canada

Book Review Editor:
PATRICK COLGAN, Ph.D.

Managing Editor: CATHERINE RIPLEY
Assistant Editor: LEANNE RIDGEWAY
Technical Editor: NOEL ALFONSO
Illustrator: ROELOF IDEMA

Graphic Design & Production:
NICOLE DUPUIS

News, views, articles for publication, and books or papers for review should be sent to:

Catherine Ripley, Managing Editor
Global biodiversity
Canadian Museum of Nature
P.O. Box 3443, Station D
Ottawa, Ontario K1P 6P4, CANADA
Fax: (613) 990-0318
e-mail: <cripley@mus-nature.ca>

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Persons wishing to subscribe, place ads, or support the publication financially should contact:
Business Manager: DAWN ARNOLD (613) 993-5908
Subscription Manager: SUSAN SWAN (613) 990-6671
Fax: (613) 990-0318
e-mail: <darnold@mus-nature.ca>

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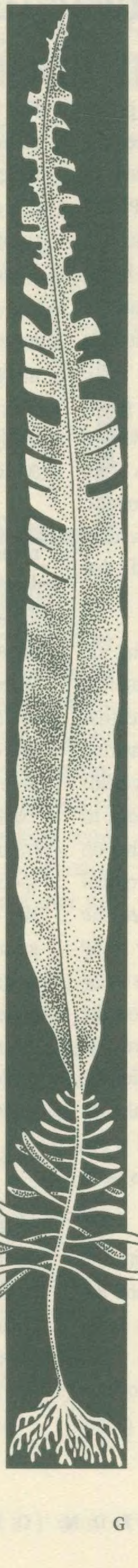

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The sea is changing, and it matters

It has proven difficult to create adequate public awareness of the fact that the world ocean is undergoing profound changes that will have an immediate impact on human well-being. Part of the difficulty arises, no doubt, from the fact that the ocean is vast — about three times as broad as the continents — so that there is a natural reluctance to believe that we have modified its habitats to the same extent that we have changed the forests, prairies, and coastal plains of the land masses. The loss of fish populations on the great fishing banks is like the loss of an old growth forest. On some shrimping grounds, the bottom is swept clean by trawls more than once a year, causing damage to bottom life that is the marine equivalent of clear cutting.

Another part of the difficulty in conveying the message of marine conservation is that few people have acquired the perspective that allows them to detect changes in the marine world. The conversion of prairie to corn fields or of mountainsides to suburbs is obvious to everyone because, being creatures that live on the land, we all have a wealth of personal experience that allows us to recognize the effects of what we have done. But how many people have seen enough marine habitats to be able to recognize a modified coral reef on the basis of their own experience? Shown the shrimping grounds of the Gulf of Mexico for the first time, how many people would be able to discern for themselves that the bare mud is not natural, but that this is a habitat that has been utterly transformed for human use?

One person who can provide us with the perspective we need in order to understand the ongoing alteration of the oceans is Sylvia Earle, a scientist who has logged more than 6,000 hours underwater and who has dived over a period of decades in oceans around the globe. She bears witness to the transformations both radical and subtle in *Sea Change*, a book reviewed on page 45. Although few individuals can match Dr. Earle's experience, her views are reinforced in another recent volume, *Understanding Marine Biodiversity*. In this case, the perspective comes from 54 individuals representing diverse disciplines of oceanography, marine ecology, molecular biology, systematics, and population biology. Their views on marine biodiversity, and an agenda for marine research strategy, are reviewed on page 44.

In view of the threat that modification of the marine environment poses to biodiversity, *Global biodiversity* devotes its first "theme issue" to the variety of life in the oceans. To help convey the richness of marine life forms and their habitats, Verena Tunnicliffe reports on diversity at deep-sea thermal vents. But one need not descend to the deep ocean floor to discover unusual life. Richard Pyle, a Hawaiian graduate student, is expanding our awareness of marine biodiversity by using advanced diving technology to reveal species and habitats at the lower limits of scuba. His discoveries of new species in the marine groups that we thought we knew best, such as angelfishes, teach us that we have only the most preliminary knowledge of what is to be found in the sea and that astounding discoveries will be made in the oceans anytime we do something in a new or different way.

Some of the threats to marine biodiversity are reviewed by Jack Sobel, who also discusses one of the possible solutions — the use of marine reserves not only for the protection of habitat but as an effective and equitable tool for managing certain fisheries. Efforts to develop international policy for the conservation of marine biodiversity are reported by IUCN's John Waugh, and a

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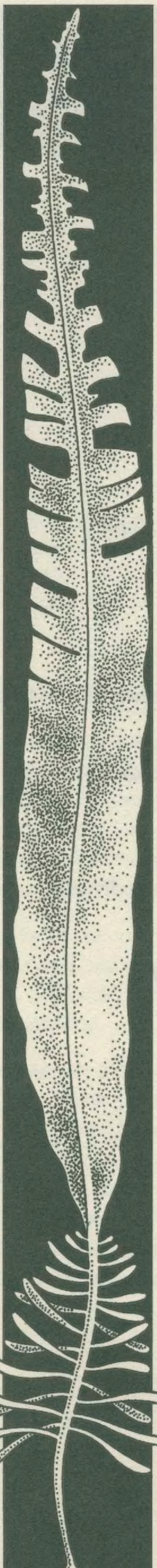

Global biodiversity is honoured and privileged to publish this issue on marine biodiversity under the special guest editorship of Dr. Michael Smith, Center for Marine Conservation. Dr. Smith worked tirelessly (and cheerfully!) to assemble a truly diverse group of authors and topics. We look forward to your comments on our first theme issue.

Exploring deep coral reefs: How much biodiversity are we missing?

Richard L. Pyle, Bishop Museum

The sunlit shallow coral reefs are easily accessed using snorkels or ordinary scuba gear. The Twilight Zone of coral reefs, from 50 to 150 metres, is scarcely explored. Conventional diving gear at the latter depths permits too little "bottom" time and is unsafe. New state-of-the-art mixed-gas, rebreathing scuba gear permits safe and long dives to experienced "aquanauts" like Richard Pyle. The early samples from his dives reveal that as much as one third of the species are new to science. [D.E.M.]

INTRODUCING THE "TWILIGHT ZONE"

In a world where human invention and inspiration more than 20 years ago put men on the moon, it seems ironic that regions of our own planet remain almost entirely unexplored. Our species has scaled the highest mountains and descended to the oceans' greatest depths, but in our determined quest to probe the extremities of the Earth, we have overlooked some important intermediate zones along the way. One of these zones, which has been the focus of my own interest over the past decade, is the deep coral reef.

Coral-reef ecosystems are among the most complex and species-rich on Earth. As with terrestrial ecosystems, the energy that drives coral-reef communities is derived ultimately from sunlight, harvested by primary producers through the process of photosynthesis. Because the intensity of sunlight in the ocean falls off sharply with increasing depth, however, photosynthesis occurs only within the shallowest 400 or 500 feet (122 or 152 metres) — less than 5% of the average ocean depth. Although marine biodiversity was once thought to correspondingly diminish with increasing depth, more recent investigations have revealed that the deep sea harbours a broad spectrum of unique and unusual organisms (Grassle, 1991). Some of these organisms are associated with hydrothermal vents (see article on page 19), but most ultimately rely on nutrients that sink from above. Comparisons of species richness and energy sources aside, the coral-reef and deep-sea environments are vastly different from each other on many levels. Whereas the brightly lit tropical reefs are characterized by complex topography and a multitude of densely packed plants and animals of all trophic levels, the cold, dark depths resemble a barren wasteland by comparison, characterized by sparsely distributed scavengers and infaunal (sand-dwelling) organisms.

The deep coral reef lies at the border between these two sharply contrasting ecosystems. Spanning depths of 200 to 500 feet (61 to 152 metres), and at the lower limits of photosynthetically useful sunlight penetration, the deep reef has been aptly referred to as the "Twilight Zone." This moniker seems particularly appropriate in view of how little we know about the organisms that inhabit these depths. As counter-intuitive as it may seem, this realm remains even less-understood than the abyssal depths. In fact, of all the world's major ecosystems, few have received as little attention from biologists as the Twilight Zone.

HISTORY OF UNDERSEA EXPLORATION

To understand why the Twilight Zone has so pervasively eluded investigation, it is useful to examine undersea exploration from a historical perspective. Early marine biologists had to rely on remote sampling gear (such as traps, trawls, dredges, nets, and hook and line equipment) for collecting specimens from all but the shallowest of undersea habitats. Although these collecting methods have provided a wealth of specimens from temperate and deep-sea environments, they are generally

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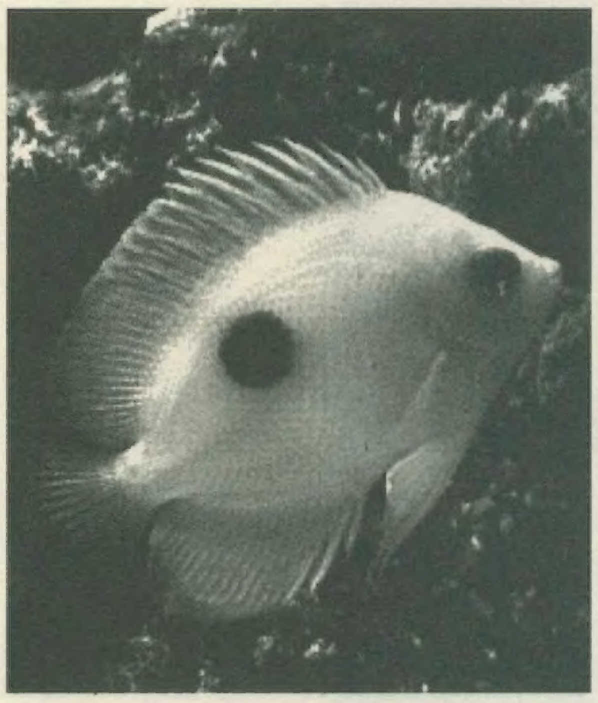
Richard L. Pyle, Ichthyology, Bishop Museum, 1525 Bernice St., Honolulu, HI 96817-0916; Phone: (808) 848-4115; Fax: (808) 841-8968; E-mail: <deepreef@bishop.bishop.hawaii.org>



This new angelfish species, discovered on the deep reefs of Rarotonga, is restricted to depths in excess of 100 metres — deeper than any other known species of its genus. It now bears the name *Centropyge narcosis*, in reference to the extreme nitrogen narcosis a person would experience attempting to dive to such depths using conventional scuba. Photo: R.L. Pyle

ineffective in areas (such as coral reefs) characterized by complex topography and an abundance of cryptic species. Furthermore, these remote sampling methods are non-selective and do not allow researchers direct examination of study subjects.

The advent of self-contained underwater breathing apparatus (scuba) technology in the 1940s opened new doors to undersea research. With minimal amounts of training and financial commitment, scuba allowed marine biologists to easily observe and collect marine organisms with a high degree of selectivity. Despite its advantages, however, conventional scuba severely limits the depth and duration of undersea scientific research. These limits are imposed by both the physiological effects of breathing elevated partial-pressures of oxygen and nitrogen (the primary constituents of air), and the limited quantities of breathing gas a diver may carry. The American Academy of Underwater Sciences (AAUS), which sets guidelines for scientific diving policies of US institutions, established an absolute maximum working depth of 190 feet (58 metres) — diving to depths in excess of 100 feet (30 metres) is generally restricted only to highly qualified researchers. Duration limitations can be overcome to some extent through "tethered" or "lockout" diving and permanent underwater laboratories; however, these alternative diving technologies have not been used extensively in scientific research because of the associated high costs, complicated logistics, and limited mobility of the operation.

To overcome the depth and time limitations of conventional scuba, marine biologists have utilized deep-sea submersible technology over the past three decades. The primary advantage of submersibles is that occupants are not directly exposed to increased ambient pressures. As a result, deep-sea submersibles have allowed researchers the opportunity to explore great depths and remain underwater for hours at a time. Unfortunately, however, submersibles have not been utilized extensively for exploring the Twilight Zone. Submersibles are extremely expensive to construct and operate, and they require extensive logistical support. The enormous operational costs of submersibles (typically $10,000 to $25,000 per day) greatly limit their availability to researchers. Consequently, the majority of undersea biological research projects using submersibles have concentrated on mid-water environments and habitats deeper than 500 feet (152 metres). For example, of 133 studies published in the last five years involving manned submersibles for undersea biological research, 29% examined mid-water organisms, 17% examined communities associated with hydrothermal vents, and the remaining 54% examined other benthic species, almost always at depths far greater than 500 feet (152 metres). Only six of these studies (less than 5%) focused on investigating tropical coral-reef habitats at Twilight-Zone depths.

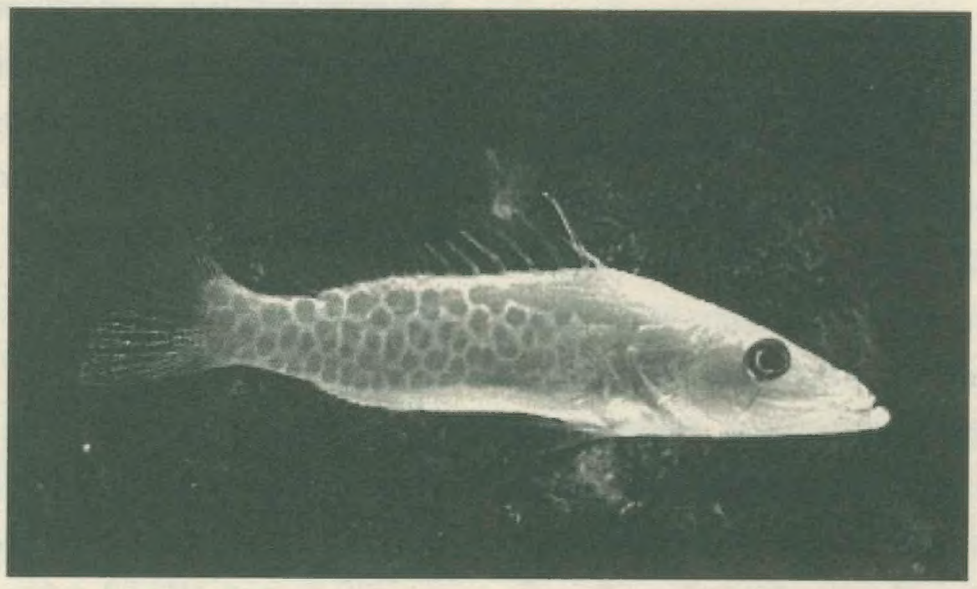
Remotely operated vehicles (ROVs — miniature submersibles equipped with lights and a video camera tethered to a surface-support vessel) have alleviated many of the problems associated with submersibles and are being used with increasing frequency for biological research. Unfortunately, these marvels of modern electronic technology are greatly limited in their ability to collect specimens, and are thus inadequate for many scientific studies.

WHAT DO WE KNOW ABOUT THE TWILIGHT ZONE? WHAT COULD WE DISCOVER?

The few studies that used submersibles that have examined Twilight-Zone marine life consistently reveal that deep-reef habitats harbour a much greater biodiversity than previously expected (Lang, 1974; Avent et al., 1977; Parker and Ross, 1986; Thresher and Colin, 1986; Hills-Colinvaux, 1986). Another consistent finding of these studies is that richness of the visible species declines dramatically below a depth of about 500 feet (152 metres). The deepest known record of reef-building corals harbouring photosynthetic zooxanthellae is 475 feet (145 metres), and the deepest record of photosynthetic algae is 460 feet (140 metres). It seems remarkable that photosynthesis takes place at all at such depths, considering that only about 1% of sunlight energy penetrates this deep (Fricke and Schuhmacher, 1983).

Unquestionably, there are many new and undescribed species awaiting discovery in the Twilight Zone. As Porter (1973) wrote in a published study of deep-reef communities in the Bahamas, "These depths are occasionally visited by opportunistic species from above, but primarily they lie in a twilight zone belonging neither to the shallower water species nor the abyssal species, but to the intermediate dwellers themselves." This suggests that many organisms inhabiting these depths occur only at this depth, and hence have escaped discovery by traditional means of exploration. Indeed, of 21 species of fishes observed between depths of 200 and 500 feet (61 to 152 metres) by Colin (1974) during a study using a submersible in the Caribbean, one third apparently represented undescribed species. Other studies have drawn similar conclusions (Hartman, 1973; Thresher and Colin, 1986).

Of course, new species of marine organisms are not the only things that await discovery in the Twilight Zone. The search for new medicines is a never-ending endeavour as new diseases emerge and as disease vectors develop resistance to conventional drugs. Broad screening of the complex extracts of biological specimens has become recognized as the most effective means of drug discovery. Many marine organisms, particularly soft-bodied sessile invertebrates, harbour complex compounds of potentially tremendous medicinal value (Fox, 1960; Jefford et al., 1988; Fautin, 1988; Faulkner, 1993). Unlike the shallow coral reefs that are dominated by large, hard-skeleton, reef-building corals, the deep reefs are characterized by a predominance of soft-bodied organisms. Perhaps not surprisingly, the percentage of organisms with biologically active compounds increases dramatically below a depth of 100 feet (31 metres) (Rinehart, 1988). Thus, Twilight-Zone exploration may ultimately lead to the discovery of cures for some of the world's most persistent and deadly diseases.



This unusual fish from the Twilight Zone probably represents an entire new genus. The author will examine many details of its anatomy, including spines, scales, bones, and other characteristics to determine its closest known relative. Although it lacks a scientific name, this fish has been referred to as the "Dr. Seuss" fish, because it resembles an imaginary creature from the popular children's book series. Photo: R.L. Pyle

Although these studies have provided tantalizing initial glimpses of deep-reef ecosystems, the scientific community has, in fact, only barely begun to probe the flora and fauna of the Twilight Zone. Unfortunately, due to logistical and financial constraints, the amount of research utilizing submersibles for deep reef exploration is not likely to increase significantly in the near future. Furthermore, almost all previous submersible research on deep coral reefs has taken place in just a few specific locales in the tropical western Atlantic Ocean, central Pacific Ocean, and Red Sea. This is unfortunate because many remote coral reef locales in the western Pacific support the greatest marine biodiversity in the world. Existing evidence suggests that one deep reef is not necessarily just like any other. For example, the abundance and diversity of sclerosponges (organisms shown to produce important bioactive compounds) were found to be especially high at depths of 300 to 320 feet (92 to 98 metres) in Jamaica (Hartman, 1973; Lang, 1974), but not at Enewetak, an atoll in the Marshall Islands (Colin et al., 1986). Therefore, the extent of deep-reef biodiversity at species-rich western Pacific locales cannot be inferred from studies conducted elsewhere.

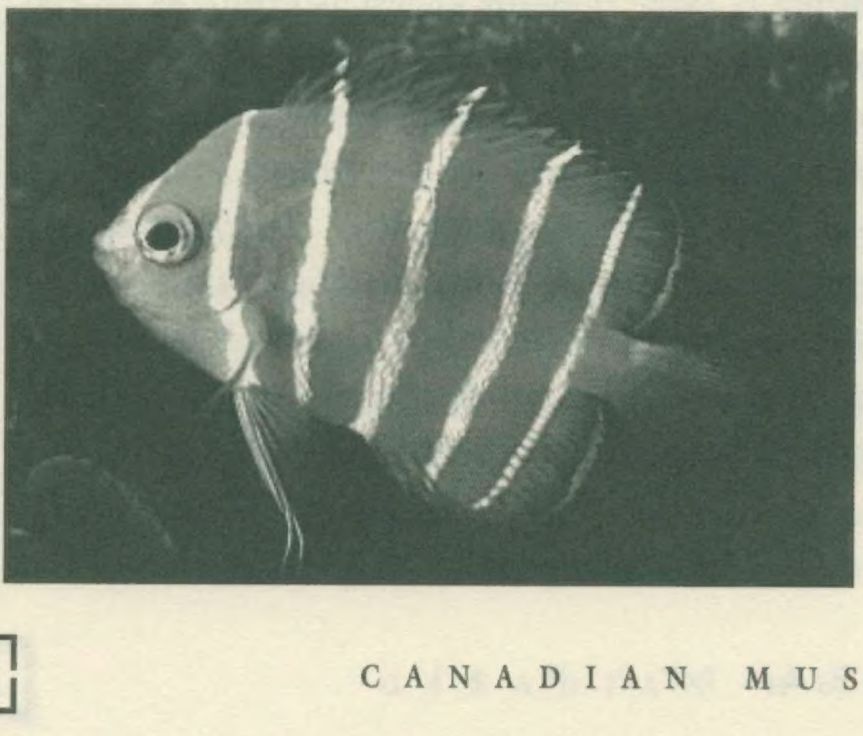
Even if funds were available to use submersibles for exploring the Twilight Zone, these studies would be cursory examinations at best. In particular, submersibles are not effective tools for collecting encrusting sponges and other sessile invertebrates, fishes, or cryptic species (Strasburg et al., 1968; Hartman, 1973; Colin, 1974; Colin et al., 1986). Also, because of physical size and safety concerns, submersibles cannot effectively approach organisms that inhabit cracks, crevasses, caves, caverns, or overhanging ledges, and thus are only adequate for broad observations of conspicuous organisms. Although some studies have been able to conduct controlled numerical data collection for quantitative analysis, the nature of submersible diving limits the extent to which such data may be collected. To elucidate the biological mysteries of the Twilight Zone, an entirely new approach to undersea exploration must be taken.

AN ALTERNATIVE: OPEN-CIRCUIT SCUBA

My own fascination with deep coral reefs began nearly ten years ago while I was living in the western Pacific islands of Belau (formerly known as Palau). As an avid scuba diver, I enormously enjoyed descending the sheer vertical underwater drop-offs, some of which plunge directly from less than a few feet beneath the surface to several thousand feet at the base. Unfortunately, my naive youthful feeling of immortality combined with my passion for discovery led to a nearly fatal case of decompression illness (the "bends"), which left me partially paralyzed for more than a year.

In the years that followed, I investigated alternative means to safely access deep-reef environments. I began corresponding with various specialists around the world about the use of helium in breathing mixtures to facilitate deep dives. Because helium does not cause narcosis, it can be used to reduce the concentrations of nitrogen and oxygen in the breathing mixture allowing divers to safely penetrate greater depths. After a great deal of experimentation and personal expense, I designed a scuba rig that incorporates four gas cylinders, five breathing regulators, and surface-supplied oxygen, allowing me to conduct safe, short-duration excursions into the Twilight Zone (Pyle, 1992; Sharkey and Pyle, 1992). During the course of a few short-duration dives to depths as great as 475 feet (145 metres) in the Cook Islands with Charles Boyle, we discovered at least 15 new species of fishes and observed many others. We also encountered an unexpected abundance and variety of various invertebrate species inhabiting these depths, including corals, mollusks, crustaceans, echinoderms, and a particularly broad array of soft-bodied sessile marine organisms.

However, in spite of our incredible scientific success during these deep dives, it became clear that our mixed-gas scuba rig was inadequate for thorough investigations of Twilight-Zone biota. With the entirely unexpected wealth of undiscovered organisms inhabiting this zone, several life-times of collecting would be required to document the deep-reef species of even a single island — even if limited only to brief "hit and run" excursions! The fundamental problem of the mixed-gas scuba rig I had designed was that it is a form of "open-circuit" apparatus, a system wherein compressed gas is breathed through a regulator, and exhaled gas is dumped as exhaust bubbles. Such systems are extremely inefficient at great depths, because so much precious oxygen is lost with each breath. At a depth of 300 feet (92 metres), for example, each breath expends ten times as much gas as it does at sea level.



Here is another strikingly beautiful angelfish (*Centropyge boylei*) also discovered on the deep reefs of Rarotonga by the author and Charles Boyle. This species differs from all other known angelfishes by the colour and number of vertical bars on the body, and was described by the author and Dr. John E. Randall. Photo: R.L. Pyle

AN EVEN BETTER ALTERNATIVE: REBREATHERS

An alternative to conventional open-circuit scuba is "closed-circuit" underwater breathing apparatus technology, commonly referred to as "rebreathers." In a rebreather, the exhaled gas is recirculated through a breathing loop, the carbon dioxide is removed by a chemical "scrubbing" agent, and oxygen is added to the breathing mixture as needed. Mixed-gas rebreathers, which blend oxygen with other gases, such as nitrogen and helium, offer three fundamental advantages over open-circuit scuba:

- longer times underwater (as much as 10 to 12 hours in a single dive);
- more efficient decompression from deep dives; and
- virtually silent operation (due to the lack of bubbles), of particular importance for marine biologists.

Despite their enormous advantages, rebreathers have not been used extensively for scientific research, and virtually not at all for deep-reef exploration. Because rebreathers have received a notorious reputation over the years as being unreliable and dangerous, most scientific institutions have not incorporated them into their academic diving programs.

Recent advances in modern microelectronics and systems design, however, have led to the development of innovative and extremely reliable mixed-gas rebreathers. These will soon be available for purchase on the public market. The most sophisticated of the new rebreathers is the Cis-Lunar MK-5P system. Equipped with three separate networked computers and a host of other features that enhance reliability, the Cis-Lunar rebreather provides up to 20 hours of underwater time at any depth, and is the ideal tool for Twilight-Zone exploration.

In late 1994, Cis-Lunar generously agreed to loan me two of their rebreathers to continue my deep-reef exploration. After a year of training, my diving companion John Earle and I accompanied Dr. John E. Randall on an expedition to Papua New Guinea, where we conducted a series of rebreather dives to depths in excess of 400 feet (122 metres). Although we did not intend this as a full-scale exploratory expedition, we discovered at least 30 new species of fishes, and observed many others. The wealth of marine life at Twilight-Zone depths in some places was astonishing.

The author descended a reef wall in Papua New Guinea using a Cis-Lunar MK-4P closed circuit mixed-gas rebreather. Advanced diving technology is providing unprecedented opportunities to explore the biodiversity inhabiting the Twilight Zone.
Photo: B. Halstead

UNANSWERED QUESTIONS

The discovery of new taxa in the Twilight Zone will have an important impact on phylogenetic and biogeographic studies of a variety of groups. For example, after examining fish specimens collected on our deep dives in Rarotonga, Richard Winterbottom of the Royal Ontario Museum in Toronto wrote, "The knowledge that these fishes occur that deep is unsettling — how can one do anything with cladograms in terms of biogeography or life histories if one is missing half the species?" Although our work thus far has concentrated mainly on fishes, surely there will be comparable discoveries of phylogenetic significance among the algae and invertebrates. Furthermore, two of the most well-known examples of so-called "living fossils," the chambered Nautilus and the living coelacanth (*Latimeria chalumnae*) are both inhabitants of the deep reef. Perhaps other species of equal evolutionary importance await discovery in the Twilight Zone.

With the increasing availability of sophisticated new diving technology, we are now finally ready to begin learning about the nature of deep-reef ecosystems. What is the true extent of Twilight-Zone biodiversity? Are most species that inhabit the Twilight-Zone endemic to those depths, or do species typical of shallower reefs predominate? How does the ecology of the reef change as the lower limits of photosynthetically useful sunlight are approached? How is the transition zone characterized? And, perhaps most significantly, what proportion of global marine biodiversity are we missing? We have only just begun to find out.

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Marine reserves: Necessary tools for biodiversity conservation?

Jack Sobel, Center for Marine Conservation

The myth that marine resources are inexhaustible is fading. But we do not yet have a grip on the principles of application of pro-marine-life management. Nor do we yet "think like an ocean," so we, as air-breathers, have scarcely seen the need to establish protected areas for the marine members of the great family of life to which we all belong. Fortunately, some reserves do exist and stand as examples of the benefits that accrue from keeping marine species and their biodiversity intact. One major shortcoming of this small network is that reserves in the continental slope and deep-sea environments are virtually absent. [D.E.M.]

VANISHING BIODIVERSITY: ITS IMPACTS

> *It may safely be said that wherever the white man plants his foot and the so-called civilization of a country is begun the inhabitants of the air, the land, and the water, begin to disappear.... The fish, overwhelmingly numerous at first, began to feel the fatal influence in even less time than the [terrestrial] classes already mentioned.... The halibut, one of the best of our fishes, was so common along the New England coast as not to be considered worthy of capture, and was considered a positive nuisance when taken. It is only within [the last] few years that our people have come to learn their excellence and value, but they have already disappeared almost entirely from the inshores of New England, and have become exterminated in nearly all waters of less than five hundred feet in depth.*
>
> Report of the US Commissioner
> of Fish and Fisheries, 1878

> *Probably all the great sea-fisheries are inexhaustible.*
>
> Thomas Huxley, 1884

These two startlingly different views of man's impact on fish populations and marine biodiversity were rendered just six years apart more than a century ago. What have we learned about their veracity since then? We can state unequivocally that Huxley, right on much else, was wrong on this subject. Fisheries collapses and crises around the globe, from the Gulf of Maine and Newfoundland to New Zealand and Australia, have conclusively demonstrated the vulnerability of our valuable marine fisheries to abuse (Safinn, 1995). Some have even argued, based on a historical review, that such crashes should be expected as the inevitable rule of resource exploitation, rather than the exception (Ludwig *et al.*, 1993).

On the other hand, the excerpt provided from the 1878 Report of the US Commissioner of Fish and Fisheries has withstood the test of time remarkably well. While set in a fisheries context, the statement ties directly to the heart of what we now call marine biodiversity loss and conservation. The US National Research Council's (NRC) Committee on Biological Diversity in Marine Systems summarized the "progress" we have made in the 100-plus years since the Commissioner's Report as follows:

> The diversity of life in the ocean is being dramatically altered by the rapidly increasing and potentially irreversible effects associated with human population expansion. Biodiversity is defined as the collection of genomes, species, and ecosystems occurring in a geographically defined region. [Among t]he most critical...contributors to changes in marine biodiversity are now recognized to be the following: fishing and removal of the ocean's invertebrate and plant stocks.... These stresses have...affected...life from the intertidal zone to the deep sea (NRC, 1995).

The striking parallels between conclusions reached by the Fish Commission in 1878 and the NRC's Biodiversity Committee in 1995 are noteworthy, but closer scrutiny

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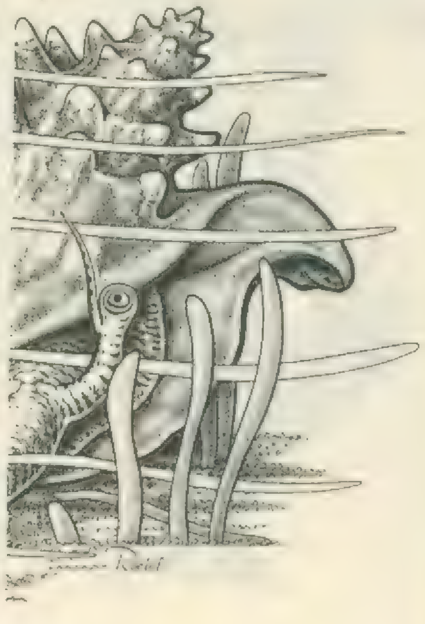
Jack Sobel, Senior Scientist, Ecosystem Protection, Center for Marine Conservation, 1725 DeSales St., Washington, DC, 20036; Tel: (202) 429-5609; Fax: (202) 872-0619

Table 1. A sampling of North American marine species, once abundant, now absent or rare in all or portions of their original ranges.

SPECIES/SPECIES GROUP	ORIGINAL RANGE	PRESENT STATUS
Northwest Atlantic Groundfish		
Halibut, *Hippoglossus hippoglossus*	■ In commercial quantities from New Jersey north and eastward to northern Europe ■ Abundant inshore and offshore throughout New England and the Canadian Maritimes	■ Greatly diminished range and abundance ■ Now found only in small scattered deep-water populations, off Northern New England, Canada, and Greenland ■ US catch is less than 1% of historic high
Cod, *Gadus morhua*	■ In commercial quantities from New Jersey north and eastward to Northern Europe ■ Abundant offshore year-round throughout New England and the Canadian Maritimes and also abundant in many inshore areas, and offshore farther south	■ Greatly diminished abundance ■ Absent or rare in most inshore waters and southern portion of former range ■ Commercial quantities limited to fractions of former range ■ US catch less than 25% of historic high
Haddock, *Melanogrammus aeglefinus*	■ Similar to cod, but less extensive	■ Similar to cod, but even more depleted ■ US catch less than 1% of historic high
Redfish (ocean perch), *Sebastes fasciatus*	■ Similar to halibut, but less extensive	■ Greatly diminished abundance ■ US catch less than 1% of historic high
Yellowtail flounder, *Pleuronectes ferrugineus*	■ New Jersey to Newfoundland with distinct Southern and Georges Bank stocks	■ Greatly diminished abundance, especially for Southern stocks where catch is about 5% of historic highs
Atlantic Coast		
American oyster, *Crassostrea virginica*	■ Eastern Canada to Gulf of Mexico and in and near estuarine environments ■ Formed, massive, highly diverse, high-relief oyster reef habitat	■ East coast populations greatly reduced ■ Landings: New England–less than 5% of historic high; Mid-Atlantic–less than 1% of historic high; Chesapeake Bay–less than 5% of historic high ■ Oysters remain scattered along coast but classic oyster reef habitat has been largely eliminated
Sheepshead, *Archosargus probatocephalus*	■ Nova Scotia to Brazil along continent only ■ Abundant in New York area for which Sheepshead Bay was named ■ Frequented oyster habitat throughout Chesapeake Bay and was important commercially	■ Absent or nearly so north of Virginia ■ Rare or absent in Chesapeake Bay ■ Appears to be recovering in North Carolina after it declined to less than 1% of historic highs ■ Still abundant further south in Gulf of Mexico
Southern US and Caribbean		
Warsaw grouper, *Epinephelus nigritus*	■ North American Coast from Mid-Atlantic to Mexico, the Bahamas and other scattered sites in mid-deep water	■ Absent or extremely rare along Atlantic Coast, and rare, at best, throughout range
Jewfish, *E. itajara*	■ Florida, the Bahamas, Greater Antilles, Gulf of Mexico, both coasts of South America	■ Absent, disappearing, or becoming increasingly rare throughout range, especially true for large individuals
Nassau grouper, *E. striatus*	■ Florida, Bermuda, the Bahamas, Gulf of Mexico, Central America and Caribbean location	■ Same as above ■ Some spawning groups have vanished, still relatively common in the Bahamas
Speckled hind, *E. drummandhayi*	■ Formerly Southeastern US, Bermuda, and the Bahamas	■ Absent, disappearing, or becoming increasingly rare throughout range
Red snapper, *Lutjanus campechanus*	■ North American Coast from Mid-Atlantic to Mexico on offshore banks and reefs	■ Still common on some offshore banks, but becoming increasingly rare, especially true for large individuals ■ More accessible banks are severely depleted
Florida Keys and the Carribbean		
Queen conch, *Strombus gigas*	■ Florida Keys and Wider Caribbean ■ provided Florida Keys island chain with its "Conch Republic" pseudonym	■ Severely depleted in Florida and much of the Caribbean ■ Moratorium on harvest in Florida Keys
Pacific Coast		
Giant sea bass, *Stereolepis gigas*	■ Central California to Baja inshore and on offshore banks	■ Severely depleted in California ■ Absent from many areas once found, especially inshore ■ Large individuals extremely rare ■ Mexican population also depleted
White sea bass, *Atractoscion nobilis*	■ Abundant from Central California to Magdalena Bay, Baja ■ Supported important commercial fishery in Monterey Bay	■ Absent or rare north of Point Conception ■ Southern California population also severely depleted
Totoaba, *Totoaba macdonaldi*	■ Sea of Cortez	■ Extremely depleted and endangered ■ Listed under US *Endangered Species Act*
California abalone stocks *Haliotis spp.*	■ Red, pink, green, and black abalones once occupied varying intertidal and nearshore habitats from Oregon to Baja	■ Pink, green, and black abalones are extremely depleted and have disappeared from many areas ■ Fisheries for these species were recently closed ■ Red abalones are also depleted and have disappeared from some areas, but remain common in others
White abalone, *Haliotis sorenseni*	■ Point Conception to Baja, California with centre of abundance around Channel Islands	■ Severely depleted and likely endangered ■ Reduced by 2 orders of magnitude around Channel Islands ■ Fishery is now closed ■ No evidence of successful recruitment in over 20 years ■ Remnant adults slowly dying off
Pacific rockfish species, *Sebastes spp. complex*	■ Diverse family of fish with about 60 species ranging from Mexico through the North Pacific	■ Overall range has not been greatly reduced, however, some species including the large red rockfish, are under increasing stress and disappearing from certain areas, especially near coastal urban centres
Lingcod, *Ophiodon elongatus*	■ Baja, California to Alaska	■ Same as rockfishes above



reveals that some knowledge has been gained during the intervening years. First, the NRC identified more explicitly the role of overexploitation as a principal agent in the loss of marine biodiversity. Furthermore, the 1878 report recognized the halibut as exceptional in its susceptibility to geographic elimination; tremendous declines in inshore, but not offshore fisheries; and reductions of cod and other species from "incredible numbers" to "moderate quantities." Recent experience in the Northwest Atlantic suggests that, while halibut are particularly vulnerable to localized extinction, they are not unique. Many marine species share similar vulnerability and have experienced stock collapse. Tremendous offshore fishery declines have followed those inshore. Stocks of cod, haddock, redfish, yellowtail flounder, and other species have declined further to minimal numbers, or have collapsed entirely (NOAA/NEFSC, 1994).

The Northwest Atlantic is not unique. A quick review shows certain marine species absent from, or rare in, all or part of their original ranges throughout North America (see Table 1 on the previous page). Marine biodiversity losses, however, are limited neither to North America nor its species. Similar losses have occurred and are occurring globally. For example, New South Wales, Australia alone has listed eight marine-protected species and banned all taking of them due to concerns about their continued survival (NSW Fisheries, 1994). According to Norse (1993), the most widely used definitions of biodiversity, like the NRC one given above, recognize three levels of importance — genetic, species, and ecosystem — and some also recognize a functional component. Even where species have not been completely eliminated, their depletion can cause biodiversity loss or change at the genetic and ecosystem levels and to function.

Genetic impacts

At the genetic level, fishing can lead to the elimination of distinct populations, races, or subspecies and/or the creation of genetic bottlenecks through population depletion or fisheries-related selection. The disappearance of sheepshead north of Cape Hatteras and of white sea bass north of Point Conception, shown in Table 1, might represent loss of distinct populations since these geographic breaks could limit dispersal, but this has not been documented. Similarly, historic grouper spawning aggregations have disappeared in the Caribbean, but did they represent genetically unique populations? That has not been determined. Published work on potential genetic bottlenecks for heavily fished populations is also limited. A Reef Fish Plan Development Team report (NOAA/PDT, 1990) summarized some of the existing information on the genetic effects of selective fishing stating that this posed a problem for reef fisheries. A subsequent review of that report concluded that genetic changes due to selective fishing was an important concern and possibility, but difficult to measure or evaluate (NOAA/AFS, 1995). However, a recent report on recovering genetic information from dried fish scales taken for age samples offers hope where such examples exist.

Ecosystem impacts

At the other end of the spectrum, the removal of organisms is definitely having an impact on ecosystems and their functioning. The impacts of removal may be:

- direct, involving primarily the species taken;
- secondary, involving prey, symbionts, or competitors; or
- cascading, involving more complex food web interactions.

Targeted species often include highly vulnerable, large, high-level predators that help structure communities (e.g. halibut, gadoids, groupers, sea bass, lingcod, and large rockfishes); easily harvested, slow-moving, benthic grazers (e.g. conch, abalone, sea cucumbers, and sea urchins) that help control aquatic plant and algal growth; and stationary, structure-producing organisms that provide important habitats (e.g. oysters, corals, sponges, and kelp) and can protect water quality via filtration. Clearly, the removal of such organisms should be expected to have a wide-ranging impact on the ecosystem. Table 2 shows examples of a variety of cold and temperate plus tropical and sub-tropical marine systems that bear witness to the ecosystem impacts of fishing.

As on land, biodiversity in the oceans is disappearing. On a global level, the IUCN recognizes the necessity of a range of protected areas, from strict nature reserves to less restrictive multiple-use areas to manage the wild resources of any nation (IUCN, 1990). North American protected areas, developed over the past 125 years, span this range and provide a partial safety net for terrestrial biodiversity, but not for marine life. North Americans, global leaders in terrestrial conservation, have only seriously considered marine protected areas (MPAs) within the last quarter century. With few exceptions, the continent still lacks marine "no–take" reserves

Table 2. A sampling of marine ecosystems and the impacts fishing has had on them.

LOCATION	IMPACT OF FISHING UPON ECOSYSTEMS
North Sea	■ Local extirpation of individual species ■ Habitat alteration ■ Changes in ecosystem structure and function (ICES, 1994)
Northwest Atlantic	■ Dominance shifts in fish community structure due to selective overexploitation (Sherman and Solow, 1992) ■ Reduced benthic habitat complexity and resulting degradation due to bottom trawling and dredging (Auster & Shackell, in review) ■ Reduction in nearshore kelp habitat due to the cascading effects of groundfish removal on sea urchin populations and ultimately on kelp dynamics (Steneck, 1996)
Chesapeake Bay	■ Impaired filtration capacity due to reduced oyster abundance ■ Elimination of critical habitat due to the removal of oyster reefs (Horton & Eichbaum, 1991; Newell, 1988; and Kennedy & Breisch, 1983)
Chile	■ Substantial restructuring of rocky intertidal communities along much of the coast due to removal of a keystone predator, *Concholepas concholepas*, and other organisms (Castilla et al., 1994; Castilla, 1986; and Castilla & Duran, 1985)
Kenyan coral reefs (where four marine parks were compared with unprotected and heavily exploited reefs; the impacts of extracting finfish were examined; the work is unique in the extent to which it examined fisheries impacts on non-fish fauna)	■ Reduced fish size and abundance ■ Reduced species richness ■ Altered fish and invertebrate community structure ■ Reduced coral cover ■ Impaired resilience to stresses of secondary importance, such as sedimentation and eutrophication (McClanahan & Obura, 1995; McClanahan, 1995 & 1994)
■ Philippines (Russ & Alcala, in press; Russ & Alcala, 1989; and Russ, 1989) ■ Belize (Sedberry et al., in press; Polunin & Roberts, 1993; Roberts & Polunin, 1993) ■ Saba (Roberts & Hawkins; 1995)	■ Dramatic reductions in high level predators and other targeted species ■ Related changes in fish community structure ■ Decreased species richness and diversity

— areas closed to consumptive use. Such reserves are essential to stem the loss of marine biodiversity, and many other countries have implemented the "no take" concept in marine areas. Their initiative now provides North Americans with a reciprocal opportunity to learn from their experiences.

BUT, DO MARINE RESERVES REALLY PROTECT BIODIVERSITY?

In 1995, the Center for Marine Conservation (CMC) undertook a review of the global status and experience with marine "no-take" reserves. In the context of this paper — and in order to avoid the confusion that currently exists because of inconsistent usage of similar terms — the term "marine reserve" will be used to indicate minimally disturbed marine areas (i.e. ocean or ocean-influenced areas below mean high tide) reserved for (i.e. dedicated to) non-consumptive human activities. The "no-take" has been added to further clarify usage in this document. Notwithstanding nomenclature problems, a careful review of global protected areas indicates that at least 25 and perhaps as many as 50 nations have implemented marine reserves fitting this definition (GBRMPA, 1995; IUCN, 1990; WCMC, 1990).

CMC's review of the global status of and experience with marine reserves included a thorough literature review, identification of and correspondence with key researchers in this field, and a workshop bringing together selected experts on the topic. The literature review revealed a tremendous increase in scientific and management interest in marine reserves during the 1980s and especially the 1990s (ASFA, 1995). Several review papers were published between 1990 and 1995 that focused primarily on the potential and effectiveness of marine reserves from a fisheries management perspective, but also discussed their other benefits. (See Table 3). The literature review also identified several countries where important research has been focused on reserves, including Australia, the Bahamas, Belize, Chile, France, Kenya, New Zealand, the Philippines, Saba, and South Africa.

In September, 1995, the CMC and the Caribbean Marine Research Center (CMRC) convened an intensive four-day workshop on marine reserves at CMRC's Lee Stocking Island facility in the Bahamas. Based on the literature review discussed above, this marine reserve workshop involved 25 scientists with hands-on experience and expertise in marine reserves from over a dozen countries representing six continents (Antarctica, which also has reserves, was not represented). These international experts presented and reviewed the global experience with marine reserves, identified their known and anticipated benefits, and discussed priority needs for future research. A full report and proceedings summarizing the results of the workshop are currently in production (CMC/CMRC, in press). (If you are interested in receiving a copy, please contact the Center for Marine

Table 3. Recently published reviews of current literature that support the concept of marine reserves.

PAPER	KEY FINDINGS/RECOMMENDATIONS
Roberts and Polunin (1991) Are marine reserves effective in management of reef fisheries?	▪ cited evidence from around the world documenting increased average size and abundance for some or all fish species within marine reserves relative to adjacent fished areas ▪ noted that reserve reefs change relative to adjacent fished ones abundance and average size of many large carnivorous fishes clearly increase within reserves, and smaller and lower trophic level species targeted by fishers show similar patterns ▪ reserves play key roles by preserving areas of reef with less perturbed community structure and by providing reservoirs for species the populations of which are reduced elsewhere through exploitation
Roberts and Polunin (1993) Marine reserves: Simple solutions to managing complex fisheries.	▪ added data from newly established reserves in Belize and Saba, and from Egypt, which reinforced their earlier conclusions ▪ raised the problem concerning persistence of vulnerable species in a mixed species fishery, in which vulnerable species continue to be fished inadvertently by fishers targeting other less vulnerable species ▪ concluded "marine reserves may be the only effective means of protecting spawning stocks of such species" (high-level predators, in particular)
Dugan & Davis (1993a) Introduction to The International Symposium on Marine Harvest Refugia.	▪ brought together over 150 scientists and managers to discuss refugia and forge a link between fisheries and protected area management
Dugan & Davis (1993b) Applications of marine refugia to coastal fisheries management. A collection of papers from the symposium mentioned above was published in a special issue of the *Canadian Journal of Fisheries* in 1993 and included a review paper by organizers.	▪ noted increased abundance, individual size, reproductive output, and species diversity in refuges of various sizes, shapes, and histories in communities ranging from coral reefs to temperate kelp forests ▪ noted fisheries yield enhancement in adjacent areas in studies where yield was analyzed, but that such studies were fewer ▪ recognized that "to enhance fisheries in areas surrounding refugia adds a level of complexity to fisheries reserves beyond that of terrestrial reserves" ▪ used the term "management by serial depletion" to describe temperate fishery management problems in California analogous to those for mixed species coral reef fisheries (discussed in Roberts and Poulunin, 1993), where fishing continues despite the near elimination of a previously targeted species ▪ stressed growing evidence of community and ecosytem effects of reserves to a greater extent than prior reviews
Pollard (1994) Preliminary report from an international workshop on harvest refugia held in Australia.	▪ noted "the only long-term solution to the problem of sustainable fisheries management may lie in the total protection from consumptive exploitation of large areas of the inshore marine environment and its living resources...coupled with the use...of more conventional, but less holistic management measures in the surrounding fished areas"
Rowley (1994) Case studies and reviews. Marine reserves in fisheries management,	▪ noted impact of New Zealand's Leigh Reserve on spiny lobster, *Jasus edwardsii*, which documents an eight-fold increase in lobster densities within the reserve, with densities still increasing after a 15-year closure, and increased lobster size and fecundity ▪ marine reserves support higher densities and larger sizes of heavily fished species than found outside reserves
Willison & Shackell (1995) Marine protected areas and sustainable fisheries.	▪ focused attention on use of reserves to address fisheries problems in cold water environments such as those in the Northwest Atlantic

Conservation at the address on page 8; a fee may be charged.)

One completed outcome of this workshop is a marine reserves benefits statement that participants agreed could reasonably be expected from an appropriate system of marine reserves based on the international experience to date. This statement is reproduced for your benefit on page 18. The benefits were grouped into four broad categories: (1) protection of ecosystem structure, function, and integrity; (2) improved fishery yields; (3) expanded knowledge and understanding of marine systems; and (4) enhanced non-consumptive opportunities. Participants agreed that the benefits grouped under ecosystem protection were among the most important and best documented; that there was some overlap among categories; that many benefits would accrue even with imperfectly designed reserves; and that certain fisheries benefits might be more sensitive to design, but needed additional testing in developed countries with strong research capacity.

The priority placed on ecosystem protection reflects the view that ecosystem protection is necessary, if not sufficient, to deliver the other listed benefits. The broad definition of ecosystem protection, as indicated by its corollary benefits, parallels the needs of biodiversity conservation as outlined above. This broader view of marine reserves as more than fishery management tools may have its US roots in a *Report on the Concept of Marine Wilderness,* adopted as a position of the American Fisheries Society (AFS) in 1988 (Bohnsack, et al., 1989). The AFS report highlighted aspects of "marine wilderness areas" (i.e. marine reserves) beneficial to fisheries; and also recognized the important roles they could play "to protect for perpetuity entire or representative portions of natural ecosystems in a state that is, as near as possible, natural" in order to "maintain natural specific diversity and composition," and to provide such unique areas, "subject to natural phenomenon only and exposed to limited anthropogenic influences" for educational and scientific use.

Shortly after AFS adopted its marine wilderness position, the Reef Fish Plan Development Team (PDT), a scientific advisory panel to the South Atlantic Fishery Management Council (SAFMC), researched and endorsed marine reserves as offering the greatest "potential for benefiting marine reef fisheries by protecting critical spawning stock biomass, intraspecific genetic diversity, population age structure, recruitment supply, and ecosystem balance while maintaining reef fisheries" (NOAA/PDT, 1990). This PDT report again recognized the ecosystem protection attributes of reserves, while emphasizing their benefits to fisheries. The PDT scientists based their recommendations on biological and ecological theory, growing empirical evidence that reserves functioned according to theory, and the demonstrated inability of other fishery management tools to address persistent problems with reef fisheries. After a series of contentious public hearings on the PDT recommendations, the Council postponed a decision on implementation pending further review. They subsequently requested that an international panel of scientists review the PDT findings (NOAA/AFS, 1995).

These broader ecosystem protection and biodiversity conservation values appear to be gaining acceptance. As one example, the international scientific panel convened in 1995 to review the 1990 PDT report, mentioned above, concluded in its Review of the Use of Marine Fishery Reserves in the US Southeastern Atlantic, that:

> (1) There is an emerging consensus among fisheries scientists and managers throughout the world that marine fisheries reserves, if well placed and of the appropriate size, can achieve many of the goals that fishery management has failed to achieve using conventional methods;
> (2) There is overwhelming evidence from both temperate and tropical areas that exploited populations in protected areas will recover following cessation of fishing and that spawning biomass will be rebuilt;
> (3) There is widespread recognition throughout the world that loss of biodiversity is largely driven by ecosystem modifications and the habitat loss that ensues. Hence preserving biodiversity implies the maintenance or reestablishment of the natural ecosystems as in marine reserves in which no extractive anthropogenic effects are allowed or are minimized (NOAA/AFS, 1995).

WHY THEN ARE THERE SO FEW MARINE RESERVES? HOW DO WE CREATE MORE?

These are interesting and difficult questions. Despite overwhelming scientific evidence, empirical observations, and common sense, many remain unconvinced or unaware that significant marine biodiversity losses have already occurred, are continuing to occur, and will continue to occur — unless we significantly change our thinking and our ways of doing business in the oceans. Science and common sense also clearly support the use of marine reserves to help conserve marine biological diversity and for other purposes. This article hints at the depth of this support, but only scratches the surface of what has already been documented. The most common reasons given by reserve opponents, reluctant bureaucrats, and cautious politicians for not moving forward with marine reserves include:

- there isn't enough science;
- there is no scientific proof that reserves work;
- reserves may be effective everywhere else, but that doesn't mean they'll work here;
- the concept makes sense, but there isn't enough information to properly design the perfect system;
- the resources aren't really in trouble, it's just a natural cycle;
- the resources are in trouble, but there's no proof removing them is part of the problem — maybe it's just water quality or habitat or global warming;
- fishing is already heavily regulated — the regulations just need time to work; and
- loss of fishing grounds is not economically viable.

Clearly, something's not working. The truth is that establishing reserves, like other public policy decisions, is a political process. Science may inform the debate and influence the outcome, but it won't make the decision. Ultimately, there must be enough public and user support for reserves to overcome the natural resistance of some special interest groups and decision-makers to changing the status quo. In North America, the momentum for reserve establishment appears to be overtaking the inertia of bureaucracy, but this remains a slow process. Canada recently established its first small reserve in British Columbia (Marliave, in press; Paisley, 1995). In the US, a proposal to establish a number of reserves as part of the Florida Keys National Marine Sanctuary (NOAA/OCRM, 1995) is slowly moving forward.

Are we "fish bigots"?

McClanahan (1990) discussed the unjustified dichotomy between terrestrial and marine protected areas in a *Bioscience Viewpoint* article entitled "Are Conservationists Fish Bigots?" He asked the reader to imagine the public outrage that would result if wolves or other top predators (e.g. bears, foxes, panthers, lions, tigers, eagles, owls, condors) were allowed to be hunted in our national parks, a situation somewhat analogous to fishing in marine protected areas. A more analogous situation would also include harvesting large trees (the trophic equivalent of kelp); grazers like deer and antelope (the trophic equivalent of conchs, sea urchins, and parrotfish); prairie dogs, other rodents, wading birds (similar in some ways to lobsters and crabs), and a whole suite of other organisms. McClanahan's analogy emphasized predator removal, because of research by himself and others documenting the cascading impacts of such removal throughout marine systems. Similarly, Martin (1995) vividly depicts the especially destructive and broad impacts of modern trawl fisheries — his focus — this way:

Why is fishing sometimes permitted in marine protected areas? Are conservationists "fish bigots", valuing terrestrial life more than aquatic life?

> Dragging is like towing two tractor blades linked with 150 feet of very heavy chain and rollers back and forth across every inch of the fishing grounds. If an oil company were to propose such a thing without an environmental assessment, we would, quite correctly, boil them in oil. But, if one calls it "fishing" conducted by "quaint" fisherfolk, then it is okay and doesn't have an environmental aspect.

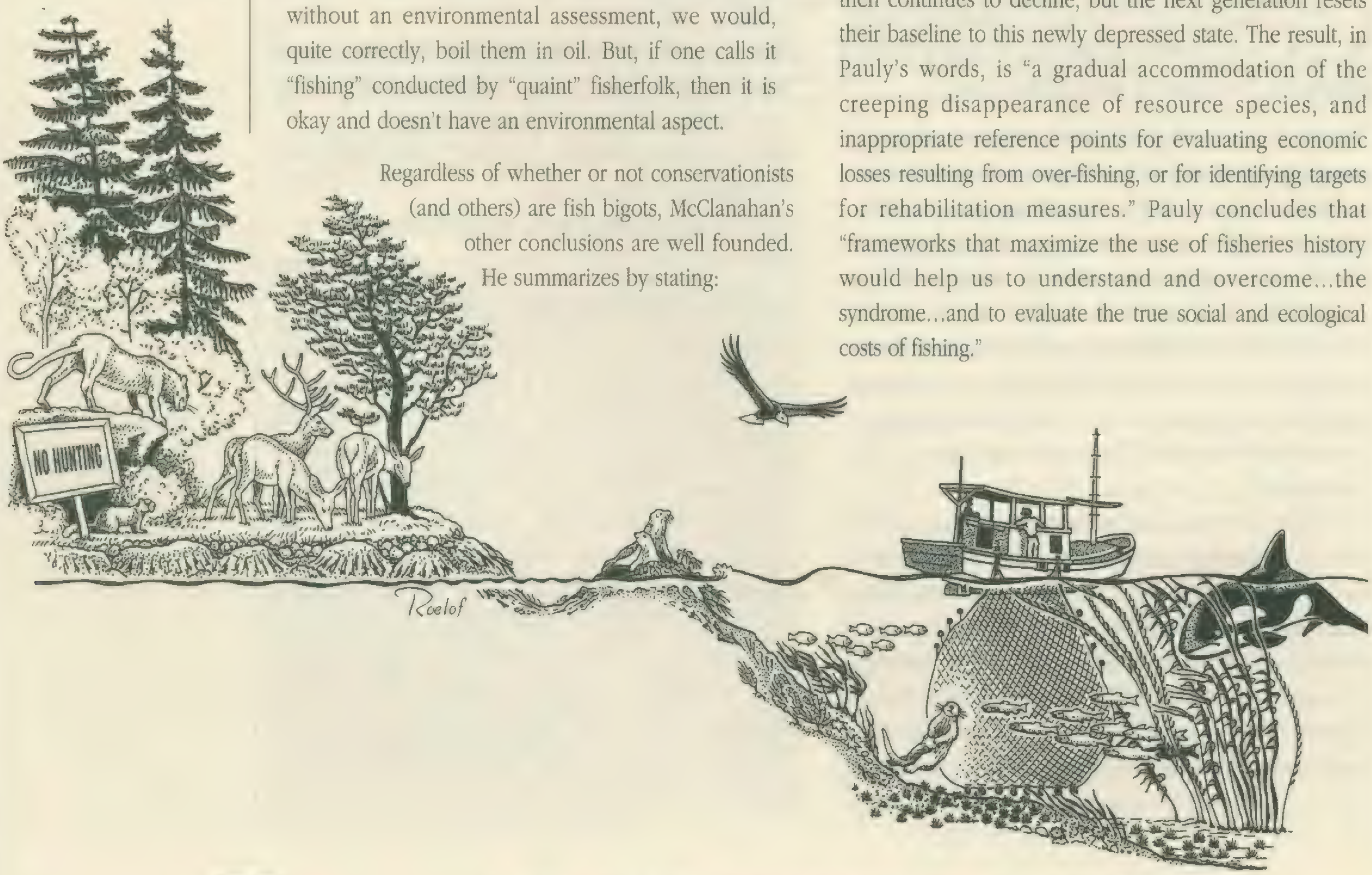
Regardless of whether or not conservationists (and others) are fish bigots, McClanahan's other conclusions are well founded. He summarizes by stating:

> One of the future roles of our parks will be to maintain pristine ecosystems that can be compared to other managed and mismanaged ecosystems. This preservation will be difficult with the parks' many external influences but will be impossible if internal management allows recreation and resource use to supersede preservation. The subjectivity of the fishing-hunting dichotomy must be relinquished to a more objective management plan that preserves aquatic ecosystems in the same manner as terrestrial species and ecosystems (McClanahan, 1990).

The implication that the public's perception is ultimately responsible for this dichotomy is also on target.

The shifting baseline syndrome of fisheries

"The shifting baseline syndrome of fisheries" also contributes to misperceptions about the state of marine resources (Pauly, 1995). Although Pauly defined this syndrome for fisheries scientists and managers, it is also applicable to the public at large. He attributes this syndrome to the fact that each generation accepts the species composition and stock sizes that they first observe as a natural baseline from which to evaluate changes. Of course, this ignores the fact that this baseline may already represent a disturbed state. The resource then continues to decline, but the next generation resets their baseline to this newly depressed state. The result, in Pauly's words, is "a gradual accommodation of the creeping disappearance of resource species, and inappropriate reference points for evaluating economic losses resulting from over-fishing, or for identifying targets for rehabilitation measures." Pauly concludes that "frameworks that maximize the use of fisheries history would help us to understand and overcome...the syndrome...and to evaluate the true social and ecological costs of fishing."



Pauly cites a series of historical examples that strongly support his contention, but some of those mentioned in Table 1 are equally compelling. Few people today would believe, let alone remember, that halibut were once commonly caught in the relatively shallow waters of Cape Cod Bay or that a large commercial fishery for white sea bass existed off of San Francisco and Monterey Bay. If anything, Pauly may have underestimated the impact of the syndrome by overestimating the average person's memory. Most people probably reset their baseline every five to ten years, rather than once a generation. Such "serial depletion of memory," is another strong argument for reserves as they provide a framework for retaining information about the "real" natural baseline.

In an article questioning plans for sustainable use founded upon scientific information and consensus, Ludwig et al. (1993) claim that such plans reflect ignorance of the history of both resource exploitation and science. They contend that historically resources have been overexploited, frequently to the point of collapse or extinction. In particular, these causative factors are at the root of the most common arguments cited by opponents to reserves.

The overexploitation has been due to:

- wealth-generated power that drives unrestrained resource exploitation;
- failure to reach scientific certainty, because of problems with controls and replicability;
- the complexity of natural systems; and
- high natural variability that masks the effects of overexploitation.

The authors provide the following principles for effective fisheries management, which are also applicable to reserves:

- include human motivation and responses as part of the system to be managed;
- act before scientific consensus is achieved;
- rely on scientists to recognize problems, but not to solve them;
- distrust claims of sustainability; and
- confront uncertainty.

The paper's conclusions are especially relevant to moving forward with reserves, recognizing that there will always be some uncertainty, especially with respect to the perfect design for fisheries management purposes.

The importance of the public: Lessons from New Zealand

Like Ludwig et al., Ballantine (1995) recognizes the importance and limitations of science, the inherent difficulties of predictability in complex, highly variable, natural systems, and the realities of how political decision-making occurs. He also contends that political decisions are usually based on perceived principles, rather than detailed predictions, and that social and scientific principles can be combined to establish reserves and improve marine management. Since he has over 25 years of experience — having successfully established a network of marine reserves in New Zealand — it is worth considering the New Zealand experience and his recommendations based on it. New Zealand's first marine reserves were established only after lengthy campaigns involving the combined efforts of academic scientists, divers, and conservationists focused on specific sites. Since then, from experience with these reserves, many reserve benefits have been discovered, by the general public and other interests. This recognition and resulting comparisons to the failures of more traditional approaches have led to increasing and widespread demand for more reserves.

Ballantine recommends widening the debate and sticking to principles as the key to establishing successful marine reserves. He argues that the discussion must include the general public and not just existing "user groups" and suggests that "common-sense" arguments that emphasize reserves as "the right thing to do" are more effective and have greater appeal to the public-at-large. The focus should be on protecting ecosystems rather than simply improving fisheries management. While the full range of potential reserve benefits should be described, it is a mistake to get caught in the trap of having to predict or prove the details of each. In his words,

> standard (traditional) resource management (data-based, resource-specific, user-oriented) will always be necessary, but is not sufficient. Principle-based, general systems including a network of "no-take" reserves are also required.... Ordinary business experience, ecological knowledge, the theory of "complex systems," the history of resource management, and recent events in marine fisheries, all suggest that stock-specific management based on scientifically-verifiable data has severe limitations...entire ecosystems should [not] be managed solely for the benefit of existing extractive users, especially when this does not appear to work very

> well even for that purpose…marine reserves [are] a useful and achievable way of up-grading the aims of marine resource management…. We should admit how ignorant we are about the sea, its life and processes, and how we need insurance.

CONCLUSION

The case for marine reserves is strong, but the obstacles to their establishment are considerable. The benefits that can reasonably be expected from an appropriate system of marine reserves are extensive and substantial. Many have been repeatedly documented and conclusively established at a number of existing reserves in a variety of environments. These include most of those classified under "Protect Ecosystem Structure, Function, and Integrity" as seen in the benefits statement on page 18. The remaining listed benefits are built on strong scientific theory and common sense, but have varying levels of empirical evidence. For some of these, especially those classified under "Improve Fishery Yields," this reflects difficulties related to complex natural systems, high levels of variation, limited controls and replicates, and inadequate monitoring programs, rather than any evidence that the reserves are ineffective. Is it fair to hold reserves to a higher standard than traditional fisheries management, which shares difficulties in proving cause and effect? Reserves continue to show promising results with respect to "improving fisheries yields," while traditional fisheries management is increasingly demonstrating its inability to prevent stock collapses and sustain fisheries.

Based on the global experience to date, the most compelling evidence on the efficacy of marine reserves concerns their role in ecosystem protection and biodiversity conservation. This, coupled with the fact that many other reserve benefits derived from ecosystem protection, suggests it is the central organizing principle around which marine reserves should be built. This case is strengthened when one considers that ecosystem protection, properly presented, probably has the greatest appeal to the broadest public sector.

Supportive arguments for reserves built on improved fishery yields, expanded knowledge and understanding, and enhanced non-consumptive opportunities are also valid and should be utilized, but should be considered secondary and recognized as appealing to more limited audiences, such as specific user groups. While such groups are unlikely to lead the campaign to establish reserves, cultivating their support or even tempering their opposition is certainly a worthy endeavour.

Multiple stresses, including direct and indirect taking of living marine resources, are interacting to seriously degrade our marine ecosystems. Success in halting this decline will be impossible without setting aside significant "no-take" reserves. Without areas relatively unimpacted by takings, we cannot properly address other stresses, understand their impacts, or even know what natural, healthy systems should look like. Nor will we be able to pass on to our children their proper inheritance of healthy, vibrant, intact marine ecosystems, key to giving them abundant opportunities and choices.

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Marine reserve benefits statement

Based on global experience, this statement was developed by 25 international experts at a CMC/CMRC Marine Reserve Workshop in the Bahamas, 26 to 30 September, 1995. The following benefits can reasonably be expected with an appropriate system of marine no-take reserves accompanied by other management measures. For some benefits, the degree of benefit will be variable for individual species and dependent on both their life histories and reserve design.

Protect Ecosystem Structure, Function, and Integrity	**Improve Fishery Yields**	**Expand Knowledge and Understanding of Marine Systems**	**Enhance Non-Consumptive Opportunities**
▪ keep biodiversity intact at all levels ▪ protect food web ▪ safeguard ecological processes ▪ maintain trophic structure ▪ protect natural population structure ▪ retain keystone species ▪ sustain species presence and abundance ▪ prevent loss of vulnerable species ▪ preserve natural community composition ▪ eliminate second order impacts ▪ maximize system resilience to stresses ▪ avert cascading effects ▪ maintain physical structure of habitat ▪ preclude threshold effects ▪ preclude fishing gear impacts ▪ avoid incidental damage ▪ retain natural behaviours and interactions ▪ maintain high quality feeding areas	▪ protect spawning stocks ▪ increase spawning stock biomass ▪ raise population fecundity ▪ enhance reproductive capacity ▪ increase spawning density ▪ provide undisturbed spawning sites ▪ ensure viable spawning conditions ▪ improve spawning habitat ▪ boost egg and larvae production ▪ provide export of eggs and larvae ▪ enhance recruitment ▪ supply spill-over of adults and juveniles ▪ reduce chances of recruitment over-fishing ▪ decrease over-fishing of vulnerable species ▪ mitigate adverse genetic impacts of fishing ▪ reduce inadvertent and bycatch mortality ▪ protect diversity of fishing opportunities ▪ maintain sport trophy fisheries ▪ simplify enforcement and compliance ▪ help reduce conflicts among users ▪ provide information from unfished populations necessary for proper management of exploited stocks ▪ improve management and increase efficiency with limited resources and information ▪ insure against stock collapse due to management failures and inadequacies and speed recovery ▪ increase understanding and acceptance of management ▪ facilitate stakeholder and user involvement in management	▪ foster understanding of natural systems ▪ provide experimental sites for natural areas ▪ permit knowledge continuity of unaltered site ▪ retain memory of natural systems ▪ enable study of relatively intact ecosystems ▪ allow study of natural behaviours ▪ provide long term monitoring areas ▪ reduce risks to long term experiments ▪ offer foci for study ▪ enhance synergy from cumulative studies ▪ allow research, monitoring, data-collection, and learning that require natural sites ▪ provide controlled natural areas for assessing anthropogenic impacts, including fisheries	▪ enhance and diversify economic activities ▪ improve non-consumptive recreation ▪ improve peace-of-mind ▪ enhance aesthetic experiences ▪ increase wilderness opportunities ▪ promote spiritual connection ▪ foster sustainable employment opportunities ▪ diversify and stabilize economy ▪ enhance conservation appreciation ▪ create public awareness ▪ reduce room for irresponsible development ▪ foster constructive social activity ▪ encourage holistic approach to management ▪ provide otherwise unavailable educational opportunities

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Lessons from deep, hot places

Verena Tunnicliffe, University of Victoria

Life at deep-sea vents is almost unbelievable. Tolerance to temperatures at the boiling point and to high concentrations of ordinarily toxic hydrogen sulphide, as well as dependence on chemosynthesis instead of photosynthesis all bespeak a unique group of species. The roots of some of these species may date back close to the origins of life and offer great potential in biotechnology. [D.E.M.]

INTRODUCTION

I have spent a lot of time on the deep-ocean floor floating over an ethereal landscape populated by bizarre-looking creatures moving in slow motion. A wonderful, out-of-body feeling creeps over you as you gaze out of the submersible window at 2.5 kilometres below the surface. Then...reality check. Even here, the human factor is present: the beer cans, the Coke bottle (with anemone), the mop, the US Government memo (Department of Commerce). Most unusual was the set of false teeth inhabited by a small fish.

For most of us, it's "out of sight, out of mind." The colloquialism refers not only to our garbage but also to entire ecosystems that we rarely encounter, and thus tend not to incorporate in our consideration of global biodiversity. Our planet still harbours many. For instance, in July 1993 the US Navy heard some unusual noises on their anti-submarine listening devices deployed off the coast of Washington state and British Columbia. A Canadian research ship immediately went over to the area off Juan de Fuca Ridge and found a large plume of hot water. A National Oceanic and Atmospheric Administration (NOAA) ship with a Canadian remote vehicle aboard from the Institute of Ocean Sciences arrived a week later to find that a volcanic eruption had occurred and new lava covered a 300 km^2 area. Hot water streaming from below the rocks enveloped the cooling lavas. Most amazing, however, was the "snow": huge clouds of white flocculated (flakey) material that were ejected from the cracking rocks along with hot water (about 55°C).

This snow turned out to be a by-product of microbial production — and the source was subsurface, below the rocks. Microbiologists from the University of Washington cultured bacteria from the venting water to find that they were "freezing to death" in the vent water; the cultures blossomed at 90°C. The hotter water must be subsurface. The current hypothesis is that the magma injected into the rocks from much deeper in the Earth's crust perturbed a subsurface system and forced much of the water, along with the microbes, onto the ocean floor. At present, we can only speculate on what type of ecosystem may exist in the deep subsurface rocks and hope that the Ocean Drilling Program will provide a window on this world.

About 15 years ago, marine biologists were equally puzzled by the first discovery of hydrothermal vents off the Galapagos Islands. It has taken many years to recognize the extent, diversity, and some of the implications of this unusual system. Perhaps the most amazing feature of hot-vent animals is the novelty of their systematics. Nearly every specialist receiving specimens has been puzzled, bewildered, and then greatly excited. Every expedition brings back new orders. As a group, the hot-vent community makes a substantial contribution to global biodiversity at higher taxonomic levels. Only 7% of the species are known beyond the vent boundaries and 50% of the described genera are new to science. This is a truly endemic community that shows little alliance with the surrounding deep sea.

Verena Tunnicliffe, School of Earth & Ocean Sciences Biology, University of Victoria, Victoria, BC, V8W 2Y2, Tel: (604) 721-6120; Fax: (604) 721-6120; E-mail: <tunnshaw@uvvm.uvic.ca>

EXTREME CONDITIONS

The explanation of these "enclaves" of novelty has two parts: one, adaptation to unusual conditions; and two, isolation in space and time. The ecosystem relies on the intermingling of vent water rich in hydrogen sulphide with oxygenated deep-sea water. Autotrophic archaebacteria (where autotrophic means capable of synthesizing complex organic substances from simple ones using energy from sunshine, as do plants, or chemicals, like these bacteria) derive their energy from oxidation reactions. These diverse bacteria live in water, in mats, and in symbiosis with invertebrates and form the basis of an extensive metazoan community. However, numerous adaptations are required to use this food source and to dispose of the toxic by-products. The giant tubeworms, up to two metres long, exemplify the extreme: they have no mouth or gut, but a long trunk filled with bacteria and an extensive vascular system to service the microbes.

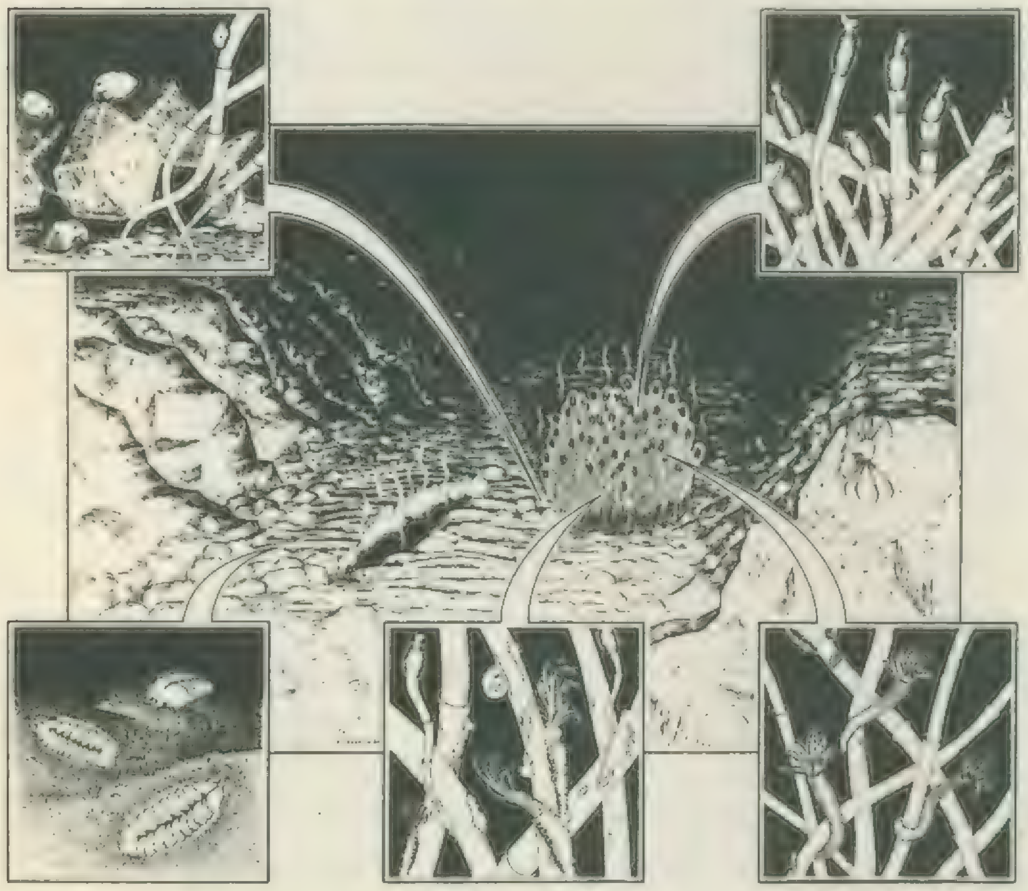


Figure 1. Cartoon of a venting fissure showing animal diversity. Top left: limpets, new superfamily Lepetodrilaceae; top right: vestimentiferans, new Order Tevniida; bottom right and middle: two species in the polychaete family Alvinellidae; lower left: scale worms, new Subfamily Branchinotogluminae.

Magma deep in the rocks heats trapped water that forms jets up to 400°C. Because of steep temperature gradients, animals live within centimetres of the smoker jets, but a minor perturbation in turbulence can kill them instantly. Many animals demonstrate controlled metabolisms in fluctuating temperatures. The superheated water precipitates its mineral load as growing chimneys and sediment. Heavy metal concentrations are very high. Metal-binding proteins and heat-shock proteins are common adaptations. Hydrogen sulphide is also highly toxic and must be immobilized, while the low concentrations of oxygen require efficient recovery; many animals are red because they use hemoglobin. All in all, it is a very difficult place to live in, but successful adaptation reaps rich rewards.

ISOLATED IN PLACE AND SPACE

Isolation is also a major factor sponsoring the differentiation of this community. Much of that isolation is due to the physico-chemical conditions described above: many "normal" deep-sea animals simply cannot penetrate the physiological barriers. Thus common groups such as the sponges, corals, sea stars, and sea cucumbers are not found in venting fluids. The habitat is also peculiar in a geographic sense. For the most part, vent fields are scattered intermittently along bare-rock spreading ridges between 1,500 and 4,000 metres deep in the ocean. The predominant mid-ocean ridge system runs like a zipper around the globe from the Vancouver Island vicinity into the South Pacific, around Antarctica via the Indian Ocean and up the Atlantic through Iceland. The re-melted subducting crust in the western Pacific also forms small spreading centres as magmas rise behind the subduction zones. Thus the habitat is highly linear, and has little contact with shallow sea areas. (See Figure 2.)

ISOLATED IN TIME

Isolation in time may also be a factor. Many systematic specialists find that their particular vent-beast displays characteristics akin to the ancestors of groups known elsewhere in the oceans. Somewhere in the past, millions of years ago, the evolutionary pathways of many vent animals seem to have diverged from those of other modern groups. Vent barnacles, for instance, have been described as living fossils. At least four different types are known and each one is close to the ancestral form seen as fossils from Mesozoic rocks. I recently received a small collection of vent animals that were retrieved near New Guinea. The geologists on the expedition recognized the importance of the creatures and kindly preserved them in overproof vodka. One little crab appears to have the ancestral characteristics of two major groups of decapod crustaceans that diverged in the Mesozoic era.

So, while the rapid change required to adapt to vent conditions could explain some systematic differences between vent and non-vent animals, it is likely that some animals have been isolated at vents for a long time. Perhaps they entered the habitat in early the Cenozoic or Mesozoic eras, became competitively dominant, and never had much reason to change. Much of the evolutionary change on our planet has occurred when extinction provided empty niches to new organisms. Thus, the mammals could radiate into modern forms after the dinosaur extinctions. Many of the major causes for extinction on the Earth would have little effect at hot vents where climate change, comet impact, and fluctuating sea levels are barely noticed. With a ready supply of food through chemosynthetic bacteria, changes in primary productivity on the surface would not cause major vent extinctions. Only an alteration in oxygen supply would be severely deleterious.

A GLIMPSE INTO THE PAST

Fossils have been found in ancient vent deposits. Although they are mostly unidentifiable tubes, they do tell us that the habitat was populated in at least the late Paleozoic and Mesozoic eras. Given these signs of antiquity, the geological history of the habitat probably has a strong influence on the development of hot-vent communities. We know that continental drift and tectonic activity greatly influence the biogeographic patterns seen in modern biotic assemblages. Surely the vent fauna, living in the "front lines" of crustal spreading, must reflect geological controls. Do communities living in different oceans, or even on opposite sides of an ocean, show an independent history? Are the past plate histories important factors in interpreting modern biogeographic patterns?

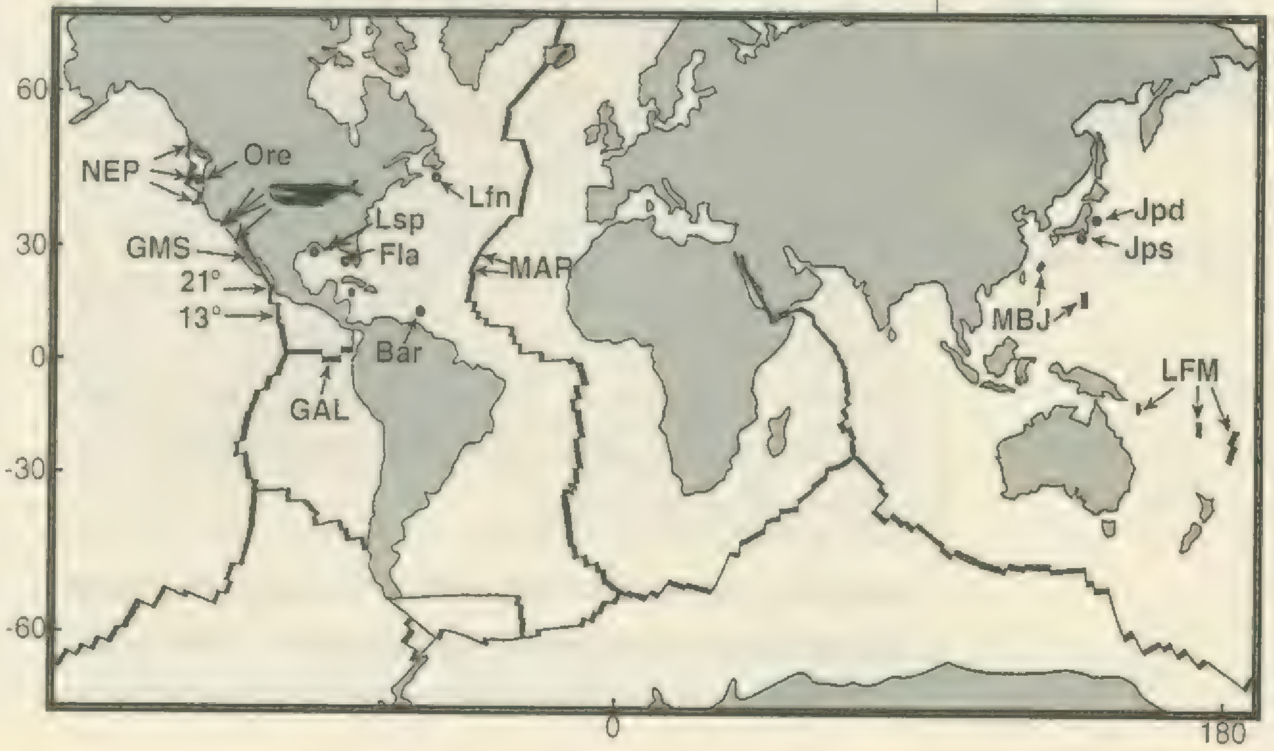
There are several approaches to such questions. First, we find that hot-vent assemblages can be treated separately from normal deep-sea fauna. Because so few species are shared, the likelihood of species spreading into several vent areas from the deep sea is very small. However, there are some other unusual habitats that may provide colonizers or even "stepping stones" for dispersal.

Second, "cold seeps" on subducting continental margins also harbour animals dependent upon chemosynthetic bacteria. Here, the subducting sediments generate the necessary sulphide and methane, and isolated communities congregate. Several years ago, some vent-related species were found living on the bones of a blue whale. Oil-rich bones generate reduced compounds for many decades. It is the detective work of many systematists that slowly uncovers the clues to the relationships among these faunal assemblages. There appears to be a group of taxa that has adapted to sulphide-rich habitats and thus relations are found at vents, whale bones, and/or seeps. For instance, the vesicomyid clams are in a Cenozoic family and have symbiotic bacteria in their gills. Other groups (the galatheid crabs and nereid polychaetes) simply appear to have a very flexible ecology and are found in many marine habitats. Since there are few species capable of living beyond the vent habitat, these can be considered a separate biogeographic unit.

Third, each region of the ocean has its own endemimc vent fauna: the Juan de Fuca Ridge, the East Pacific Rise, the equatorial western Pacific, the Japan area, and the middle Atlantic. Only a few species are found in more than one area. But the higher taxa are shared. Thus, genera and families known only to hot vents are found in many different places: for example, alvinellid polychaete worms (named for the *Alvin* submersible) are everywhere in the Pacific, and dirivultid copepods are found in both the Pacific and Atlantic. At generic levels, vent animals in different regions are more closely related to one another than they are to the deep-sea fauna only a few metres away.

Fourth is the matter of dispersal. Most marine invertebrates have pelagic larvae that may float long distances. Biogeographers frequently must determine the relative importance of existing gene flow and colonization versus historical geologic events. Current population-genetics work on vent animals indicates that there can be high gene flow within a region but that the long distances, transform faults, or continental barriers between regions effectively block much exchange. Vent sites on the East Pacific Rise off Baja, California are equidistant between Juan de Fuca Ridge and the Galapagos Rift. Yet there is little similarity with the former because the interposing North American Plate destroyed the original linking spreading ridge about 25 million years ago. However, a contiguous ridge is present along the East Pacific Rise and along the propagating Galapagos Rift; geophysicists have documented the unceasing activity of spreading and magmatic activity in this region during the Cenozoic era.

Figure 2.
Mid-ocean spreading ridge system. Major vent sites where biological collections have been made are indicated in capital letters. Seep communities are indicated by dots and small letters and the whale icon shows where whale skeletons have been found.



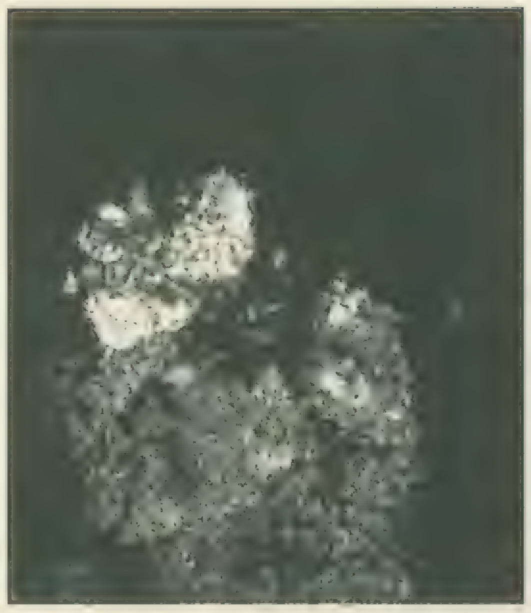


Figure 3. Black smoker on Juan de Fuca Ridge at 1,500 m depth. Chimney is 3 m high and water is 330°C.

Interpretation of past plate and ridge positions helps to explain the origin of regional vent fauna. Twenty-five million years ago, the animals off the west coast of Canada began to lose contact with their southern parents and today we see many new species in groups still closely related to the East Pacific Rise region. This fauna will continue to diverge. Meanwhile, ridge propagation in the western Pacific has provided an invasion pathway to the Fijian area from the East Pacific Rise. Many groups, including some species, are found in both regions.

Exploration in the Atlantic is most intriguing. There, the vent communities lack many Pacific elements, such as giant tubeworms and clams. Instead, biomass is dominated by shrimps and mussels, among others. But still, these taxa are known only from Pacific vents, so there is an evolutionary connection — not a separate origin — in the Atlantic. But how did the ancestors arrive as the Atlantic Ocean formed? The equatorial barrier from the eastern Pacific, the Isthmus of Panama, is young — of the Pliocene era. From the Mesozoic to mid-Cenozoic eras, the Tethyan Sea and Caribbean region provided an open ocean conduit to the Atlantic. Yet faunal similarity analyses related the Atlantic vent fauna much more closely to western Pacific than to eastern Pacific faunas. It seems the Caribbean pathway was most likely shallow and did not include sustained deep-water ridges. Thus, it is via the antipodal ridges of the Pacific and Indian Oceans that the vent fauna spread to the Atlantic. These connections have remained since the Mesozoic era. Today several genera and even one species is found at vents in both Fiji and the northern Atlantic. Only with further exploration in the southern ocean can the full extent of the interchange be elucidated.

CONCLUSIONS

Many valuable lessons can be learned by studying these habitats. One is the difficulty related to researching and exploring the deep sea. Extraordinary cooperation is required to reach this world: among agencies, among researchers, and among technologists. It is a truly profound experience for the lucky student. Some unlikely partnerships are emerging and such cross-fertilization can only benefit all disciplines.

For those interested in biodiversity, these deep-sea vents and similar habitats are a major resource. Clues to the relationships between major groups lie with these animals. The vent gastropods, for instance, show very deep divergences in phylogenetic trees constructed from DNA sequences. Thus, some of the genetic diversity thought lost from our planet through extinction may be sequestered in these deep-water refugia. As well, these extreme habitats could also be the source of innovations that spread to the rest of the globe — we may be able to discover where, in evolutionary history, animal/microbial symbioses first developed. Can we learn more about host-to-alien cell recognition factors?

Needless to say, the potential for biotechnical exploration is also great. You can already buy primer sequences for PCR, from a commercial supply house, that were isolated from vent microbes. The possibility of anti-microbial agents isolated from organisms living in such extreme conditions is also under exploration. And what about the potential for environmental remediation products? In a society of run-away pollution, such communities — adapted to thermal stresses, heavy metal contamination, and toxic sulphides — must harbour some very useful compounds.

A bewildering array of questions remains to be answered by research. Not the least of which is, "What further wonders does our planet hold?"

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The global policy outlook for marine biodiversity conservation

John Waugh, IUCN-US

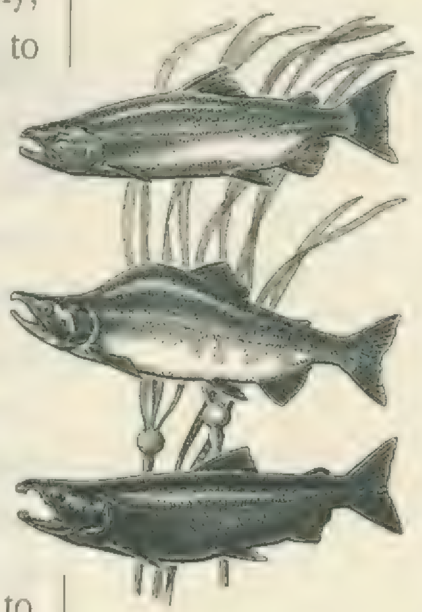
A number of national and international initiatives are responding to the environmental and fisheries crises in the World Ocean. What are these initiatives? Are the responses appropriate? Will adequate resources be provided to make them work? [D.E.M.]

INTRODUCTION

In March 1995, Spain and Canada clashed over fishing practices in the North Atlantic, and the world awoke to a global fishery crisis. Increased fishing pressure and declining fisheries is only one aspect of a syndrome affecting the global ocean. Other symptoms of poor health of the ocean ecosystem include toxification of the seas and deterioration of sensitive habitats. Particularly noticeable is the widespread decline of coral reef ecosystems. The scale of the ocean makes it difficult for humans to grasp the problems that beset it. The oceans appear, for all practical purposes, to be limitless. The tradition of the "global commons," with free and open access to the seas' natural resources for anyone willing to bear the risks involved, reflects this sense of limitlessness. It has always been easy to see the vast ocean as a sink capable of absorbing anything we put into it without apparent impact. It is a profoundly important cultural change that humanity is beginning to comprehend, albeit painfully, the very real limits of the Earth's bounty. These limits should be reflected increasingly in new international law and policy.

Several key policy elements have been or are being put into place with the potential to facilitate a more comprehensive approach to the conservation and sustainable use of marine biodiversity. The objective of this article is to provide an overview of policy developments underway, and identify opportunities for scientific and technical input into these political processes.

Major components include the United Nations Convention for the Law of the Sea (UNCLOS), the United Nations Environment Program's (UNEP) Global Programme of Action for the Protection of the Marine Environment from Land-Based Activities (GPA), the decisions made at the Second Conference of Parties to the Convention on Biological Diversity (COP-2) on marine issues (which has become known as the "Jakarta Mandate"), the initiation of the development of a new protocol on ballast-water management to prevent the introduction of alien species by the International Maritime Organization of the UN (IMO), the development of an FAO Code of Conduct for Responsible Fisheries, and the conclusions of the UN Conference on Straddling Stocks and Highly Migratory Species. Simultaneously, other elements are well underway in the global arena to address such issues as endangered marine species and marine protected areas.



Spawning male salmon

GLOBAL ACTIONS UNDERWAY

UNCLOS and global fisheries reform

UNCLOS, long anticipated, came into force on 16 November 1994. UNCLOS provides a comprehensive framework in relation to a host of regional agreements and processes. It requires governments that are parties to the Convention to cooperate with each other and to recognize existing international rules and standards for sustainable ocean use or adopt new ones. It is, in effect, a global constitution for the governance and sustainable management of the seas. The central issue, which UNCLOS was designed to address, is the recognition that the global ocean commons provides no basis for the management of living marine resources, but does provide an ongoing potential for conflict. UNCLOS is based on a

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John Waugh, Senior Program Officer, IUCN-US, 1400 16th Street N.W., Washington, DC 20036; Tel: (202) 797-5454: Fax: (202) 797-5461; E-mail: <iucnus@igc.apc.org>

carefully negotiated compromise involving, on the one hand, the extension of national jurisdiction of coastal states to the 200-mile exclusive economic zones for the management and use of fisheries, which will allow the possibility of bringing living marine resources under some type of management regime, and on the other hand, protection of traditional rights of free passage. (For background on UNCLOS, see *Global biodiversity* 4(1): 26–30.)

UN conference on environment and development

The Rio Earth Summit of 1992 set in motion a range of issues relevant to marine biodiversity. Perhaps most notable were the two global treaties negotiated in parallel, the Convention on Biological Diversity and the Framework Convention on Climate Change. Less visible, but important from the perspective of marine biodiversity, was the initiation of the processes leading up to the creation of the GPA, and the UN Conference on Highly Migratory and Straddling Stocks. Both were concluded in 1995. In addition, the Earth Summit produced Agenda 21, an overarching global program of action on environment and sustainable development, which provides a basis for international cooperation. Governments established the UN Commission on Sustainable Development (CSD) as the primary review and follow-up mechanism. 1997 marks the five-year point for Agenda 21, and CSD will undertake a comprehensive review of the steps to date to implement the agreements arising from the Earth Summit.

The Straddling Fish Stocks and Highly Migratory Fish Stocks Agreement

The Earth Summit called for states to "take effective action…to ensure that high seas fisheries are managed in accordance with the provisions of the United Nations Convention on the Law of the Sea." Of particular concern were fisheries populations with ranges that extend beyond exclusive economic zones (called straddling stocks) and highly migratory species. Neither class could be adequately protected under existing rules. The United Nations Conference on Environment and Development (UNCED) called for an intergovernmental conference to identify and assess problems related to the conservation and management of straddling and highly migratory fish stocks and formulate appropriate recommendations, consistent with the provisions of UNCLOS. A conference process was initiated under UN auspices in 1993, and concluded in 1995. The subsequent agreement (the Straddling Stocks Agreement) requires states to prevent and reduce excess fishing capacity, and to use more selective fishing gear and techniques. It also delineates coastal state responsibilities for enforcement of regulations, in the context of regional fisheries agreements. The agreement provides the principle upon which to base specific regulatory regimes in regional agreements.

FAO Code of Conduct for Responsible Fisheries

The Committee on Fisheries (COFI) of the UN Food and Agriculture Organization (FAO), anticipating UNCED, called, in March 1991, for the development of new concepts for sustainable fisheries. FAO also provided the principal technical inputs into the Straddling Stocks Conference and concluded the Agreement to Promote Compliance with International Conservation and Management Measures by Fishing Vessels on the High Seas (the Flagging Agreement) in 1993. The FAO subsequently decided to compile principles and standards related to the "conservation, management, and development" of fisheries, based on these and other developments, which would be non-binding. The product, the FAO Code of Conduct for Responsible Fisheries, is intended to provide a framework for sustainable use of living aquatic resources. Key features include general principles linking the sustainable use of fisheries to conservation of aquatic ecosystems, and linkages between target species and associated species within the ecosystem, through integrated coastal area management. The FAO has also made connections between fisheries and other human impacts on aquatic habitats, by linking sustainable fisheries and pollution prevention, for example. It provides specific guidance in fisheries management and operations. This includes specific, complementary roles and responsibilities of flag states (from where vessels originate) and port states. Some guidance is provided concerning fishing gear and destructive fishing practices, and aquaculture practices.

CSD review of oceans issues under Agenda 21

The need for additional international effort in fisheries was a major subject of discussion at the CSD intersessional working group in March 1996. At a panel organized by IUCN and the Biodiversity Action Network (Bionet), Lisa Speer of the US-based Natural Resources Defense Council established an agenda to advance fisheries reform. It called for:

- A 60% reduction in worldwide bycatch by the year 2000, consistent with FAO estimates of the reductions possible, and subsequent further reductions.

- A ban, to be imposed by countries and regional fishery management organizations, on any increase in net fishing capacity and effort for any fishery classified by a government, regional organization, or the FAO as fully fished, over-fished, or depleted.
- Expedited reductions in fishing capacity and effort for over-fished and depleted fisheries, giving priority to those involving significant bycatch, habitat alteration, or other harmful environmental impacts.
- A ban on the introduction of additional large industrial-style vessels (e.g. factory trawlers) into fisheries classified as fully fished, over-fished, or depleted.
- A targeted, significant reduction in the overall capacity of the world's fishing fleet that reflects the assessments of the FAO and others of needed capacity reductions.
- An evaluation by the FAO of capacity and subsidies on a country-by-country basis, including impacts on non-target species and measures for enhancing gear selectivity, using a conservative reference point (not maximum sustainable yield) in assessing "available resources" in relation to capacity. Within the study, a focus on vessel decommissioning schemes, job retraining programs, etc., in addition to other capacity reduction efforts were called for.

Another panelist, Serge Garcia of the FAO, suggested that the basis for over-fishing lay not so much with overcapacity, but with open access. Such free access results in an undervaluing of resources, with excessive capacity and over-fishing as consequences. He urged that the focus be on addressing the underlying cause, and not only the consequences. Short-term actions could include improved gear selectivity and the reduction and more efficient use of bycatch. In the long term, access regimes that respect the carrying capacities of the stocks and ecosystems would have to be employed.

The panel highlighted the considerable complexities of managing the marine environment, but also indicated a common basis for departure: fisheries must be managed within sustainable limits to avoid further ecological, economic, and social catastrophe. The parameters of biodiversity must be more clearly articulated in the context of fisheries to include variables in addition to a simple calculus of monospecies maintenance and loss. Such variables, consistent with the language of the Convention on Biological Diversity (CBD), would consider maintenance and sustainable use in the context of ecosystems, species, and populations.

CSD, in its April 1996 meeting, is expected to produce a draft resolution for the UN General Assembly endorsing the GPA, and affirming support for the International Coral Reef Initiative (ICRI).

Effects of land-based activities and the GPA

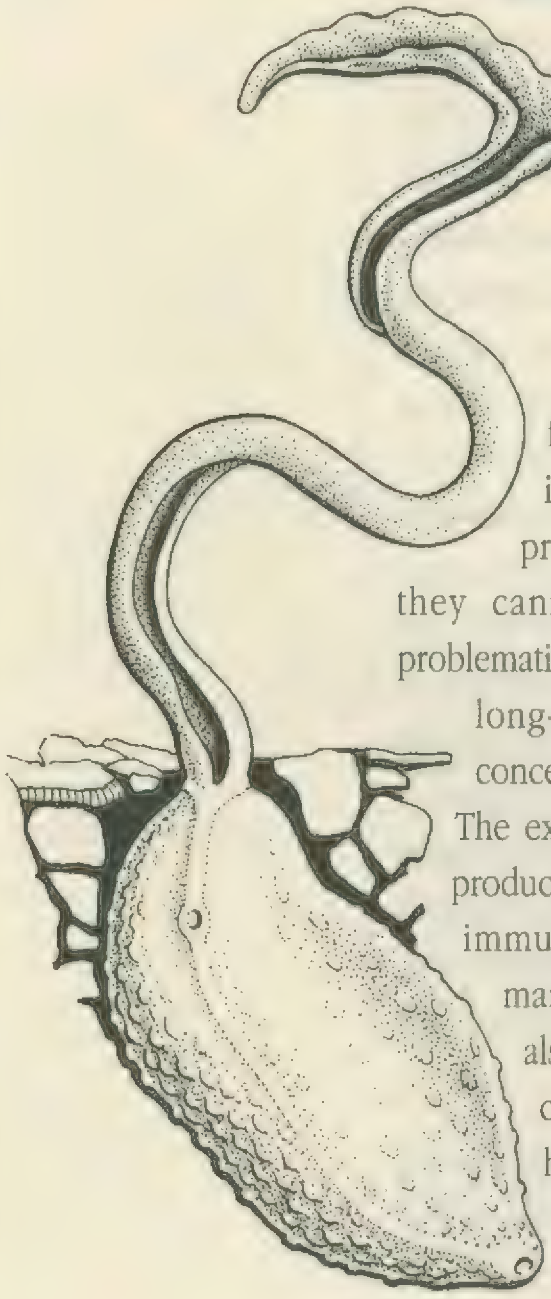
For several decades, scientists and managers have identified land-based sources of marine pollution as an area of particular concern. Early efforts focused on enclosed and semi-enclosed seas, producing agreements in 1974 in the Baltic and North Seas. Since then, several UNEP Regional Seas Programs have generated agreements to address land-based sources. Then, in 1993, acting on the recommendations of Chapter 17 of Agenda 21, UNEP initiated a diplomatic process to produce the GPA. This process addressed not only land-based sources of marine pollution, but also land-based activities that have an impact on the marine environment. These include activities that result in sediment transport through watersheds into coastal and marine habitats, as well as having a direct impact on the habitats themselves. Governments concluded negotiations on the GPA at the Washington Conference in November 1995. The GPA identifies nine general classes of threat to be addressed: sewage, persistent organic pollutants, radioactive substances, heavy metals, oils or hydrocarbons, nutrients, sediments, litter and debris, and habitat destruction.

In March 1996, an IUCN and Bionet panel indicated that global fisheries must be managed within sustainable limits to avoid further ecological, economic, and social catastrophe.

The accomplishments of the GPA are significant, and set the stage for additional work to curb land-based impacts. It provides for a clearing-house mechanism to organize information in three areas — source categories (including impacts), methods of addressing problems, and the available expertise and resources to address them. It will then exchange this information globally. The GPA offers a systematic methodology to rank impacts not only in relation to the environment, but also in connection with other key concerns of governments, such as human health and food security. From this ranking, the GPA can develop specific national and regional action plans to address the most immediate problems. The GPA also calls for common methods to monitor and evaluate progress in addressing land-based activities. Article 197 of UNCLOS significantly strengthens the GPA by requiring parties to cooperate internationally to formulate and elaborate rules, standards, and recommended practices for the protection and preservation of the marine environment.

Governments have now charged UNEP with developing an implementation plan and taking the lead in carrying out the GPA. We should expect to see synergies with the international finance institutions, including the World Bank and the regional development banks, especially in the development of operational strategies and guidelines related to funding. Significant additional work is required to identify the factors affecting decisions by governments, industry, and communities in addressing land-based activities. The positive and perverse economic incentives provided by tax and regulatory policies must be examined in more detail. Application of the "polluter pays" principle will require agreed-upon mechanisms for the assessment of the full environmental costs, as well as market-based and regulatory mechanisms for collecting these costs. The elimination of perverse economic incentives to pollute should have a far greater impact over the long term than new and additional sources of financial assistance to address these issues — even under the rosiest scenarios. However, and especially in the short term, "bandages" are required in the form of urgently needed financial assistance for the development of waste treatment facilities — and not only in developing countries.

During the high-level (ministerial) segment of the Washington Conference, a declaration was issued calling for, among other things, a process to produce a global ban on persistent organic pollutants (POPs). An international experts meeting on POPs, held in Vancouver, in June 1995, described POPs as organic compounds that have long half-lives, and resist degradation. They are lipid-soluble (can be dissolved and stored in fats), making them bioaccumulating and biomagnifying, accumulating at the higher levels of the food chain. They are usually produced as insecticides and herbicides, or as industrial by-products. Once released into the environment, they cannot be retrieved. They are particularly problematic in the polar regions where they are carried by long-range atmospheric transport and become concentrated in the fatty tissues of marine species. The experts stated that POPs have been observed to produce effects on the endocrine system and induce immune system dysfunction in a variety of mammalian and non-mammalian species. They also cause reproductive abnormalities. Some are carcinogenic. Most POPs, experts agree, are human-made.



Echiura
Bonellia viridis

Marine biodiversity and the CBD

In November 1994, COP-1, held in Nassau, the Bahamas, adopted coastal and marine biodiversity as the first thematic area to be considered under the Convention's program of work. A Marine Biodiversity Workshop within the Global Biodiversity Forum, (organized by IUCN, the World Resources Institute, and the Bahamas National Trust) in the two days preceding COP-1, contributed to bringing this item into the Medium-Term Program of Work of the COP. This workshop allowed well-known marine biodiversity experts to interact with the COP delegates in wide-ranging discussions concerning the complexities of applying the CBD in the coastal and marine environments. Because of its emphasis on implementation at the national level, some aspects of the CBD implementation scheme are problematic in the case of marine biodiversity. Ocean circulation does not honour legal boundaries, and the boundaries of marine communities tend to be in flux, crossing and extending beyond areas of national jurisdiction. A sense emerged from COP-1 that further consideration of the problems of marine biodiversity was necessary and that solutions were possible.

The next step was for the Convention's Subsidiary Body on Scientific, Technical, and Technological Advice (SBSTTA), an in-house panel of government-appointed experts to advise the Parties on the technical aspects of biodiversity conservation, to examine the issues. The first meeting of SBSTTA took place at UNESCO headquarters in Paris in September 1995 (see *Global biodiversity* 5(3): 19–21 for details on this meeting and its resolutions) just after a meeting, organized by IUCN and Bionet, of experts from NGOs and governments to review issues. SBSTTA identified a need to focus on actions in five thematic areas: integrated coastal and marine area management; marine and coastal protected areas; sustainable use of coastal and marine living resources; mariculture; and alien species. Its recommendations to COP-2, held in Jakarta in November 1995, endorsed integrated marine and coastal area management as "the most suitable framework for addressing human impacts on marine and coastal biological diversity." It called on governments to strengthen their integrated management capacities and for additional research and monitoring programs. It recommended that the CSD evaluate the over-capitalization of fishing fleets globally, and the impact of this on marine biodiversity, and called for a review of the role of subsidies in overcapitalization. SBSTTA encouraged the CSD to highlight the need for international cooperation to stem the adverse impact of alien species introductions.

COP-2 affirmed that the SBSTTA recommendations provided a solid basis for future elaboration of the issues presented. It instructed Executive Secretary Calestous Juma to develop recommendations as options for consideration by the COP, drawing upon a roster of experts with expertise in scientific, technical, technological, social, managerial, economic, legal, and indigenous and traditional knowledge. The Executive Secretary is authorized, over the next three years, to convene meetings (limited to 15 experts selected with regard to geographic representation, and for periods not to exceed five days) to provide input into such recommendations. The Parties called for the roster to be used to:

- identify options for pragmatic but comprehensive approaches to marine and coastal biodiversity;
- identify particular conservation needs in the context of impacts on marine resources; and
- review the mandates under international agreements affecting marine and coastal biodiversity, and develop analyses of the implications for the CBD of these agreements.

COP-2 also produced specific guidance for the implementation of the Convention under each of the five thematic issues. It also produced recommended policy guidance to, and collaboration with, other international bodies. Coordination with other specialized international bodies, such as the UN's Group of Experts on the Scientific Aspects of Marine Protection (GESAMP) and UNEP, is a key challenge of the CBD in coming years.

Sharing of benefits and the CBD

Emerging documentation on the high levels of biodiversity in the water column and the existence of unique forms around vents in the deep seabed have raised some questions about benefit-sharing. COP-2 asked that the Executive Secretary, in consultation with the UN Division for Ocean Affairs and Law of the Sea (DOALOS), study the relationship between the CBD and UNCLOS regarding the conservation and sustainable use of genetic resources on the deep seabed. Insights into this relationship should enable SBSTTA to address the scientific, technical, and technological issues relating to bioprospecting of genetic resources on the deep seabed. This process will require additional scientific and technical inputs.

The problems of ballast water and the IMO

Meanwhile, another key aspect of marine biodiversity conservation has been under consideration at the IMO in London. Ballast water is the most commonly identified (but not the sole) vector for the introduction of alien and invasive species. A proliferation of regulations on ballast-water management and discharge is a matter of concern to governments and to the shipping industry, and standardization of approaches is considered a priority. At the 37th meeting of IMO's Marine Environment Protection Committee in September 1995, the Parties agreed to draft a legally binding protocol to the International Convention for the Prevention of Pollution from Ships (1973 — known as MARPOL and detailed in José Ottenwalder's article on page 31) as amended through the 1978 Protocol Negotiation, for the regulation of discharge of ballast water and the prevention of alien species introductions in coastal waters. Negotiation of a protocol is expected to take several years. Issues to be resolved include the variability of the risk posed by ballast-water discharge and the best options for their mitigation, including port reception facilities and open-water ballast exchange.

Related to this topic, Norway convened a meeting of experts on alien species in Trondheim in May 1996. Recommendations from this meeting are expected to have an effect on the evolution of thinking concerning the protocol.

Degradation of coral reefs and the ICRI

The ICRI is a voluntary program of cooperation involving the governments of Australia, France, Jamaica, Japan, the Philippines, Sweden, the United Kingdom, and the United States. UNEP, the World Bank, UNDP, and IUCN are also partners. ICRI was designed to respond to the global concern over the destruction of coral reefs and related ecosystems reflected in Agenda 21 and many of the follow-up activities to UNCED. Announced at the Global Conference on Sustainable Development of Small Island Developing States and COP-1, the ICRI focus on integrated coastal management is also highly relevant to the GPA. This growing partnership has received strong endorsements from global- and regional-level bodies concerned with conservation and sustainable use of the marine environment.

A global workshop in the Philippines in 1995 produced two documents designed to set out the concerns and the actions necessary to address the threats to reefs, *Call to Action* and *Framework for Action*. ICRI has convened

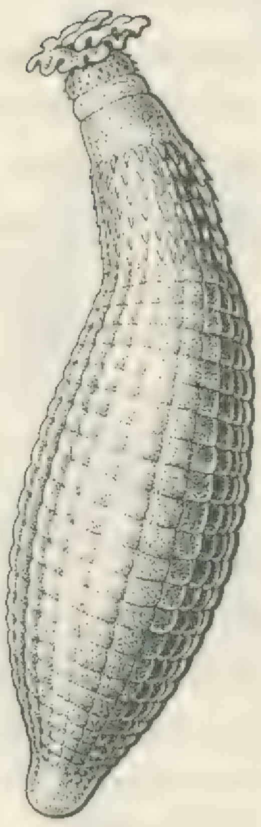
For those interested in finding out more about the CBD process, IUCN and Bionet has produced an "issues and options" paper on COP-2. In addition, Bionet has produced a "user-friendly guide" to the Jakarta Mandate. Finally, a handbook on the application of the Convention in the coastal and marine environment has been produced by the Center for International Environmental Law (CIEL), in conjunction with WWF and IUCN, and should be available in mid-1996.

regional workshops in five coral-reef regions around the world to translate these documents into regional action plans. ICRI will report results to the Fourth meeting of the UN Commission on Sustainable Development and the Eighth Coral Reef Symposium in Panama in June 1996, as this goes to press. Future directions may include a strong role for ICRI in 1997 — the International Year of the Reef — and in additional regional work, especially addressing the community-based management of reef resources.

ICRI partners have stressed the importance of global research and monitoring networks. ICRI has been successful in pushing for the establishment of a Global Coral Reef Monitoring Network under the Intergovernmental Oceanographic Commission of UNESCO, UNEP, and IUCN. ICRI may also be expected to address information requirements globally, moving beyond coral-reef status to detailed case studies on the underlying causes of reef loss and management options to address reef threats. Links to the clearing-house mechanisms of the CBD and GPA should be sought.

Marine protected areas

In June 1995, IUCN, the World Bank, and the Great Barrier Reef Marine Park Authority released a milestone study recommending a global representative system of marine protected areas. The study found that there are 1,306 marine and coastal sites under some form of protection. It also found that many marine protected areas were only nominally under protection and actually lacked any on-the-ground management presence. A survey of recommended priority areas for additional conservation work provides a strong foundation for future work to develop systems of marine protected areas. IUCN has maintained a support network of marine-protected-area managers and other authorities since 1990, under its Commission on National Parks and Protected Areas.



Peanut worm,
Sipunculis sp.

Some existing international agreements provide a basis for cooperation in developing a global network of marine protected areas. The World Heritage Convention identifies and protects areas of special significance to all humankind. The World Heritage List includes 14 sites with marine components and 17 sites with coastal components, including the Galapagos Islands and the Great Barrier Reef. Coastal and marine areas remain significantly under-represented, however, and additional work could be done to recruit new sites, while continental slopes and the deep-sea environments are virtually unrepresented.

Under the Convention for the Protection of Wetlands of International Importance (Ramsar), coastal areas up to six meters in depth at low tide are eligible for listing, permitting listings of biologically significant areas such as coral reefs, estuaries, and seagrass beds. Approximately 270 Ramsar sites have a marine or coastal component. Parties to Ramsar agree to conserve listed sites. In March 1996 in Brisbane, Australia, the Conference of Parties considered ways to increase coastal wetland representation of sites listed for protection under Ramsar.

The Man and Biosphere Programme (MAB) of UNESCO is an international cooperative effort to protect large areas by balancing core conservation sites with surrounding zones permitting various degrees of human activity under a large management plan. Given the concentration of human settlement in coastal areas, and the scope and scale of interactions at the land and sea interface, the MAB model is a particularly interesting one for marine protection. Approximately 25% of the 314 MAB sites have a coastal or marine component.

Protected endangered species through CITES

The 10th Conference of Parties to the Convention on International Trade in Endangered Species (CITES) will meet in 1997. Two marine-related studies have been commissioned for this COP: one concerning sharks and one concerning trade in live corals. CITES has not yet established a strategy for addressing fisheries issues, and additional debate concerning marine listings can be expected at the next meeting.

Conservation and sustainable use and IUCN

IUCN will host the first World Conservation Congress, incorporating its General Assembly, in Montreal, Quebec from 13–23 October 1996. This triennial meeting provides the largest regular global gathering of governments and non-governmental organizations to address conservation and sustainable development on a global basis. The Montreal Congress will feature workshops on biodiversity, sustainable use, fisheries, marine protected areas, integrated coastal area management, and marine law and policy, among other things. Interesting discussions, which could arise relevant to the marine biodiversity policy outlook, would be possible inputs into the 1997 UN review of the UNCED implementation, such as issues of interagency coordination and cooperation, and the role of NGOs in these processes.

A CRISIS IN SCIENCE

A key conclusion of the IUCN/Bionet process in preparation for the CBD meetings mentioned previously was that the development of effective marine and coastal biodiversity policy is compromised both by a lack of knowledge and by poor distribution and organization of information that already exists. This is especially true in marine systematics and biogeography, the sciences that quantify the amount and distribution of marine and coastal biodiversity. Further work must also be done to understand the economic forces that drive decisions contributing to the loss of biodiversity. All the policy-making institutions and processes described here should contribute to the development of a set of priority, policy-oriented research questions to better assess the causes and motivations and predict the consequences of changes in marine and coastal biodiversity due to human activities.

Donors, in particular, should be encouraged to support basic marine and coastal assessments, and the maintenance of data in formats useful in decision-making. Particular areas of concern include support for institutions that house the results of marine and coastal biodiversity research (e.g., herbaria and museums), and support for training, especially of parataxonomists to work at the community level. Funding for biodiversity programs should include support to maintain reference collections and their associated databases at the source of information. Urgent steps are needed to reverse deterioration of marine reference collections worldwide. The World Council on Collections Resources and the Systematics Agenda 2000 identify means of forestalling the permanent loss of irreplaceable scientific resources. These measures are not adequately addressed in the global outlook, and yet enhancing our basic understanding of the biological and economic processes associated with the coastal and marine environment is essential. In addition, a standing experts body is needed to monitor trends in marine biodiversity, identify emerging issues of concern, and build on the Global Biodiversity Assessment undertaken in support of the CBD. Such an experts' panel was proposed under SBSTTA, but rejected by governments.

Here is a basic challenge to biodiversity conservation. What is the basis for management in the face of incomplete knowledge?

All too often, despite the evidence of ecosystem degradation and biodiversity loss, the absence of adequate knowledge is used to justify failures to develop effective policy. Herein lies a basic challenge to biodiversity conservation. What is the basis for management in the face of incomplete knowledge? The precautionary approach provides a reasoned response consistent with the challenge to develop resource use sustainably. This approach requires prudence in undertaking potentially harmful activities in the face of uncertainty, and a redistribution of the burden of proof so that it falls more evenly on regulators and users alike. We should never fall victim to sophistry concerning the basis for sustainable behaviour.

A CALL TO ACTION

Much of the progress in advancing coastal and marine biodiversity conservation of coming years will depend upon the willingness of governments to tackle difficult issues individually and to cooperate in international processes. This brief overview has only touched on the global issues, and doesn't even begin to address regional ones. It is nevertheless evident that there are many institutions and intergovernmental processes at the global and regional levels that could potentially have an impact on marine biodiversity. Each has a different history and different mandate; and be warned, governments do not always behave consistently across the range of legal instruments and institutions to which they are party.

Difficulty in coordinating these international bodies has led to considerations of global governance, and even calls in some quarters for intergovernmental oversight mechanisms, such as an Intergovernmental Panel on Oceans or Fisheries. At the London Workshop on Environmental Science, Comprehensiveness and Consistency in Global Decisions on Ocean Issues, co-sponsored by the governments of the UK and Brazil in December 1995, most experts rejected the idea of any new intergovernmental agreements or bodies. Governments are now looking to *coordinating* mechanisms, rather than *governing* ones, as an answer.

One proposal has been for the UN Administrative Coordinating Committee to take a greater role through its Subcommittee on Oceans and Coastal Areas (SOCA). SOCA consists of the task managers for ocean-related activities in the specialized Agencies and Secretariat of the UN. Much will depend upon how successful SOCA is at producing dialogue between the UN system, the relevant international organizations and agencies such as the Bretton Woods (international financial institutions), and the outside world, including both civil society and the private sector.

> ***I encourage the readers of* Global biodiversity *to stay informed...[to] share your expertise with your own governments and with the international organizations charged with addressing these [marine biodiversity] issues.***

Another proposal has been made by the Worldwide Fund for Nature: for the UN General Assembly to take on an overseer role in oceans governance in the context of the annual oceans review. This review, originally restricted to UNCLOS-related issues, has already been expanded to look at fisheries, including driftnets, bycatch, and illegal fishing. The success of this approach would be in part determined by the amount of time available to effectively address the issues, and the willingness to look beyond the UN system for both problems and solutions.

Because it is so important that your expertise and commitment be mobilized, I have provided a list of key contacts. I encourage the readers of *Global biodiversity* to stay informed about these forthcoming decision-making processes. Working through both formal and informal channels, you can share your expertise with your own governments and with the international organizations charged with addressing these issues. The unprecedented level of activity in marine and coastal biodiversity policy we are now experiencing is an important chance to "get it right."

SELECTED CONTACTS IN COASTAL AND MARINE BIODIVERSITY POLICY

Biodiversity Action Network
Dr. Sheldon Cohen, Coordinator
1400 16th St NW
Washington DC 20036 USA
Tel: (202) 547-8902
Fax: (202) 544-8483
E-mail: bionet@igc.apc.org

Convention on Biological Diversity
Dr. Calestous Juma, Executive Secretary
World Trade Center
413 St. Jacques St., Office 630
Montreal H2Y 1N9 Canada
Fax: (514) 288-6588

FAO
Fisheries Division
Mr. Serge Garcia, Director
Viale delle Terme di Caracalla
Rome, 00100 Italy
Tel: ++39 65 225 4376
Fax: ++39 65 225 3020

IMO Marine Environment Protection Committee
4 Albert Embankment
London, SE1 7SR UK
Tel: ++44 171 587 7611
Fax: ++44 171 587 3210

International Coral Reef Initiative
Dr. Peter Thomas, Coordinator
Department of State
OES/E
Room 4325
Washington, DC 20520
Tel: (202) 736-7113
Fax: (202) 647-5247

IUCN - World Conservation Union
Dr. Magnus Ngoile
Head, Marine and Coastal Programme
28, rue Mauverney
CH 1196 Gland, Switzerland
Tel: ++41 22 999 0254
Fax: ++41 22 999 0025
E-mail: NMA@HQ.iucn.ch

IUCN Environmental Law Centre
Mr. Lyle Glowka
Adenauerallee 214
Bonn 1, Germany
Tel: ++49 22 8 262 231
Fax: ++49 22 8 269 2250
E-mail: elcb@hq.iucn.ch

IUCN/US
Mr. John Waugh, Sr. Program Officer
1400 16th St NW
Washington DC 20036 USA
Tel: (202) 797-5454
Fax: (202) 797-5461
E-mail: jwaugh@iucnus.org

UNEP
Dr. Terttu Melvasalo, Director
Oceans and Coastal Areas Program Activity Centre (OCA/PAC)
P O Box 30552
Nairobi, Kenya
Tel: ++254 2 621234
Fax: ++254 2 622788

UN Division of Ocean Affairs and Law of the Sea (UNDOALOS)
Mr. Moritake Hayashi, Director
DC2-0240
Room S 3427A
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UN Group of Experts on Scientific Aspects of Marine Protection (GESAMP)
c/o Intergovernmental Oceanographic Commission
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1, rue Miollis
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Tel: ++33 1 45 68 40 14
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Conservation of marine biodiversity in the Caribbean: Regional challenges

Dr. José A. Ottenwalder, United Nations Development Program

Where biodiversity is rich, human population growth high, incomes low, and coastal zones actively developing, careful consideration needs to be given to conservation and sustainable use. Such an area is the Caribbean. [D.E.M.]

INTRODUCING THE CARIBBEAN

The Wider Caribbean encompasses a vast marine area (4.31 million km^2 — the Caribbean Sea alone covers an area of about 2.64 million km^2), bordered by 36 nations, including continental countries, island nations, and dependent territories. This represents the largest number of national jurisdictions of any region of similar size in the world. In human terms, the region is characterized by a variety of people, cultures, and political systems, representing a variety of different types and stages of economic development. In natural terms, the region harbours exceptional biodiversity, estimated as the greatest concentration of biodiversity in the Atlantic Ocean Basin. The marine seascape is characterized by high biological productivity along the coast, supported by a complex interaction of three major ecosystems — coral reefs, mangrove forests, and seagrass beds, but low productivity in the deep-ocean regions.

With impressive and diverse marine and coastal habitats, Caribbean nations largely depend on the health and beauty of the natural world to generate income. As a result, economic activities and human populations are heavily concentrated along coastal areas. The well-being of the region's marine biodiversity is, therefore, not only linked to social, cultural, and political conditions, but also to the economic realities and fiscal constraints of the states and territories of the region.

At present, the ultimate responsibility for the region's marine resources is subdivided among the 36 tightly packed nations. But are 36 separate strategies the most effective way to protect and sustainably use the rich natural heritage — especially since the environmental problems in the region are diverse and complex? Some of these independent sovereign states have populations the size of large towns in other countries. They subsist upon meager resource bases and are utterly dependent on a steady flow of cash from the outside while they deal with their problems of economic development in the face of environmental degradation. The logic of regional cooperation to manage these problems is inescapable. So far, however, efforts to achieve regional integration in the Wider Caribbean have not been heartening.

This is not to say that no regional efforts exist. Efforts to politically and economically integrate the Caribbean go back to the 17th century. During the last 50 years alone, we have seen the creation and disappearance of a succession of umbrella organizations primarily, if not exclusively, made up of the English-speaking Commonwealth states. However, in 1994, an inclusive constituency was forged with the development of the Association of Caribbean States (ACS) to bring together Commonwealth states and non-Commonwealth territories (Cuba, the Dominican Republic, France, Haiti, the Netherlands, and the United States).

Other centrifugal forces are also at work in the region. These include territories involved with multi-national trade preferences, the vertical integration of some industries (i.e. bananas, sugar, bauxite, petroleum), and the focus on the area by key conservation organizations, namely the World Conservation Union (IUCN) and the International Maritime Organization (IMO). In fact, IUCN has regarded the Caribbean as a priority area since the

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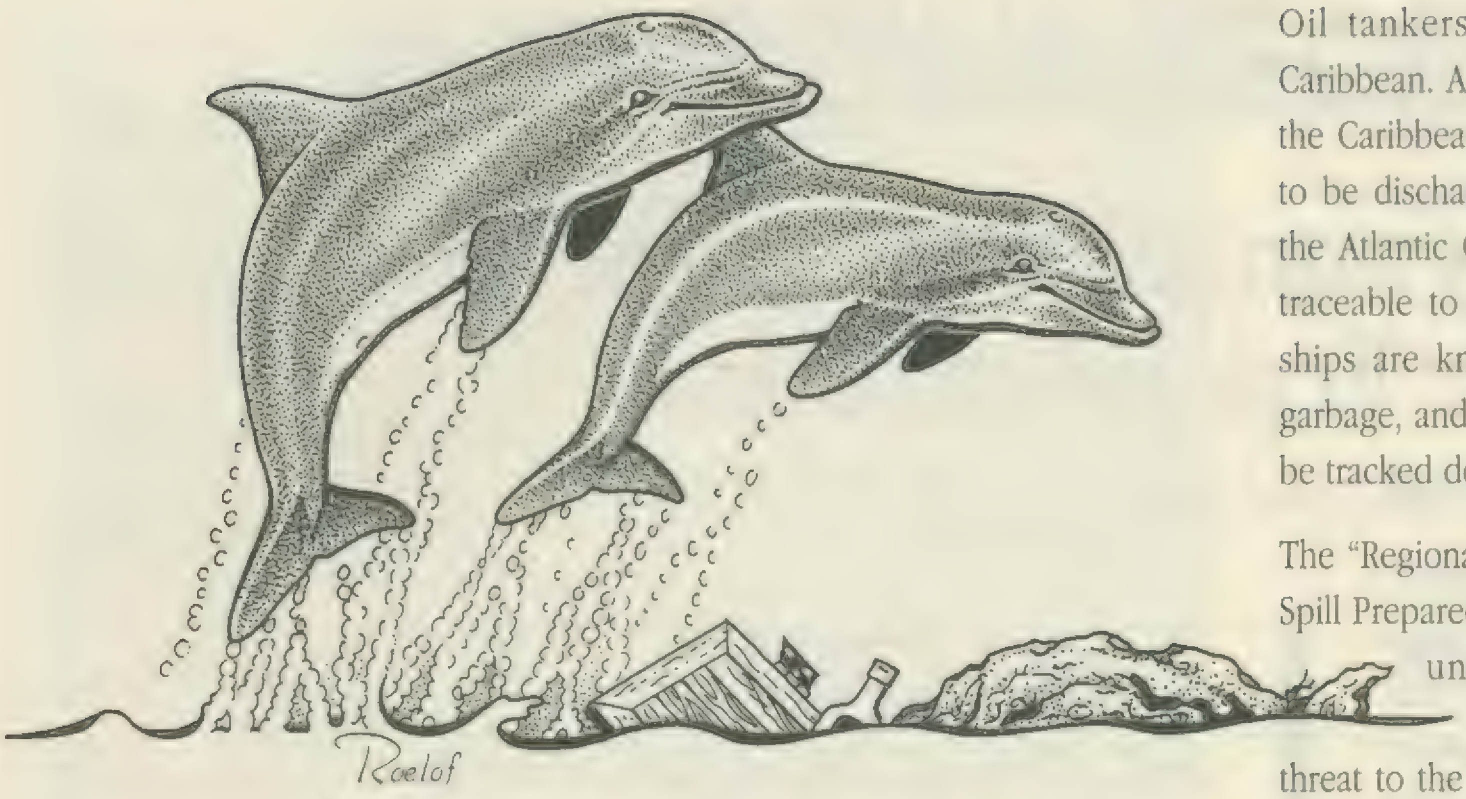
Dr. José A. Ottenwalder, ONAPLAN Coastal Marine Biodiversity Project, GEF Coordinating Office, United Nations Development Program, Apartsado Postal 1424, Calle Ramón del Orbe #23, Mirador Sur, Santo Domingo, República Dominicana, Tel: (809) 534-1134; Fax: (809) 530-5094; E-mail: <pnud-dom!jottenwalder@codemail.attmail.com>



late 1970s, and more recently it has been declared a "particular sensitive area" by the IMO (1992). Sharing genetic resources, preventing marine pollution, developing research and monitoring needs, establishing effective protection, and establishing sustainable fisheries management are some of the critical issues that have been approached in a regional context. Insights into the effectiveness of these regional initiatives are examined below.

DEALING WITH POLLUTION

Pollution knows no national boundaries, and it impairs productive fisheries and viable tourism areas. As such, it poses a serious threat to sustainable economic development for all the countries in the Caribbean. There are two major questions with which the region has been grappling: how to control pollution from external sources; and how to control pollution generated within the region.

Pollution from external sources, and other external threats

The Caribbean is one of the most heavily traversed portions of the global sea, and marine pollution from transboundary and extra-regional activities is significant. Oil tankers carrying products northward from Trinidad and Venezuela and those carrying Alaskan oil from Panama to US gulf ports and US Virgin Islands are common. Indeed this is one factor that gives this semi-enclosed sea such strategic importance, but it also poses a great threat. One positive precaution was the development of a specific protocol under UNEP's Action Plan for the Wider Caribbean (1981) with its accompanying Cartagena Convention (1983): The Protocol for Combatting Oil Spills.

Oil tankers aren't the only ships to traverse the Caribbean. A number of countries and private sectors use the Caribbean, which causes sizable amounts of garbage to be discharged in the region. Debris also comes from the Atlantic Ocean, and much of this material is directly traceable to cargo shipping and fishing vessels. Cruise ships are known to produce considerable amounts of garbage, and the source of disposed waste cannot always be tracked down.

The "Regional Workshop for the Wider Caribbean on Oil Spill Preparedness and Response and 'Special Area' Status under Annex V of Marpol 73/78" held in Caracas, Venezuela, concluded that the threat to the Caribbean Sea from garbage was significant enough to seek special protection. After a resolution from the Caracas workshop was endorsed by IMO's Marine Environment Protection Committee, the Wider Caribbean region was designated as a "special area" under the provisions of Annex V of Marpol 73/78. The designation came into effect in April 1993. Under the terms of Annex V relating to Special Areas, ships of any size are prohibited from discharging any waste material except food waste, which may be discharged 12 nautical miles (3 nautical miles in the Wider Caribbean) from land. However, the "special area" designation will be effective only one year after the waste reception facilities in the ports of the region are established and operating. Furthermore, a regional Global Environmental Facility (GEF) funded project, the Wider Caribbean Initiative for Ship Generated Waste (WSISW), which began in 1994, is actively seeking to ratify and implement Marpol 73/78 throughout the Wider Caribbean region. The Marpol Treaty Annex V provides a legal framework to deal with polluters, and since it was implemented on 31 December 1988, there has been no proof of cruise-ship related debris within the jurisdiction of signatory countries. Unfortunately, the majority of Caribbean countries are not signatories to the Marpol Treaty.

Internal sources of marine pollution

Marine pollution also stems from many sources within the territorial limits of the region. Contaminants include petroleum and its derivatives, leachate from solid waste of landfills on coastal areas, domestic wastes (sewage), and industrial and agricultural run-off. Waters and sediments drain into the Caribbean from continental drainage systems (Mississippi, Rio Grande, Magdalena, Orinoco) as well as numerous watersheds of the insular Caribbean and Central America, carrying with them pollutants. The CARIPOL program for research and monitoring in the petroleum area has been active for more than 15 years, and receives regional support. However, there is no similar data for other pollutants such as sewage, agrochemicals, and industrial effluents.

DIRECT PROTECTION OF MARINE BIOTA

In addition to pollution, major stresses on Caribbean marine biodiversity are the physical destruction of coastal-marine habitats, and overexploitation. Direct impacts (such as resource extraction, dredging and filling, over-harvesting, and indiscriminate waste disposal), in general, concentrate between the coastline and the edge of the shelf, whether insular or continental. Several regional initiatives are either in place or currently in the making to reduce coastal environmental impacts from these activities. Generated by the UN Global Conference on the Sustainable Development of Small Island Development States (SIDS) held in Barbados in 1994, the Programme of Action of SIDS adopted recommendations for implementing national, regional, and global mechanisms for the sustainable management and protection of coastal and marine resources and their biological diversity, along with sound environmental policies for tourism development and waste disposal in small islands. A draft Protocol on Land-Based Sources of Marine Pollution has been completed by UNEP with assistance from IOC. Another regional UNEP initiative, the Caribbean Environmental Network Project (CEN), aimed at assisting the Wider Caribbean region to reduce coastal degradation caused by tourism while achieving sustainable development, is being launched under the framework of Caribbean Environmental Program (CEP) and the Cartagena Convention. About 14% of the world's coral reefs are found in the Caribbean. Traditionally, the characteristic subsistence fisheries of the region have focused on the harvesting of marine biota on coral reefs and banks. A regional Agenda for Action of the International Coral Reef Initiative (ICRI) was developed in Jamaica in 1995.

Through fisheries management

Because many fish species range widely and swim in, through, and out of many exclusive economic zones, management of these species logically requires broader approaches than national ones. As detailed in John Waugh's article on global policy efforts (see page 23), international measures are being put into place to ensure that these species are protected, and both UNCLOS and the FAO Code of Conduct for Responsible Fisheries emphasize regional cooperation as key to successful implementation.

Through controlling introduction of exotic species

A number of alien species have been introduced in the Caribbean as a result of aquacultural projects — many of which have failed to achieve economic success. The resulting impact has been negative for the native Caribbean biota. Again, the UNCLOS framework requires

states to take measures to control the accidental or intentional introduction of exotic species.

Through marine protected areas

Jack Sobel's article on marine reserves (see page 8) points out the benefits of protecting marine areas. UNEP's Cartagena Convention for the Protection and Development of the Marine Environment (1983) includes a protocol on Specially Protected Areas and Wildlife (SPAW). This protocol calls for a regional network of protected areas to conserve and restore regional ecosystems, including specific components such as coral reefs, mangrove forests, and seagrass beds. Most marine protected areas (MPA) in the Caribbean are not exclusively marine, but constitute an extension of coastal protected areas: 96 include significant marine elements; 58 include coastal terrestrial or intertidal habitats only. Unfortunately, while all major ecosystems are included, only 20% are properly managed.

RESEARCH AND MONITORING

To adequately protect marine biodiversity, it is vital to understand the composition, structure, and functions of marine ecosystems. Traditionally research has been focused on single-species stocks, single sites, or on small spatial scales, but this does not allow scientists and managers to fully understand the range of ecosystem variability. Therefore, long-term studies need to be carried out on an expanded geographic scale, including comparative work at multiple sites within ecologically coherent regions as defined by patterns of endemism and their connection by ocean currents. This sort of work fits perfectly into a regional approach — regional research, which has been carried out using remote sensing technology, suggests that regions, such as the Caribbean Sea, can be treated as large marine ecosystems in their own right. Success of such regional research, however, depends on the cooperation of all nations in the area. One encouraging project was the creation of the Caribbean Coastal Marine Productivity Program (CARICOMP) in 1986. This program is now based at over 20 marine research laboratories, while an additional 14 universities/laboratories associated with one or several aspects of the research program are likely to formally join the network.

CONCLUSION

One of the most fully developed programs in UNEP's Regional Seas Program is the Caribbean Environmental Programme. However, UNEP has noted several constraints hampering the full delivery of the CEP, namely: insufficient political commitment by participatory countries; organizational weaknesses in implementing and coordinating the program; and inadequate awareness, expertise, and experience at the national level. For those familiar with the Caribbean, these factors are the rule rather than the exception.

Regional success in managing marine resources is ultimately rooted in the success of individual Caribbean states to build their internal capacities and commit wholeheartedly to the regional concept. Local participatory management experiments, which allow local stakeholders to play a leading role in identifying priorities, problems, and implementing management strategies, are vital. They are the building blocks upon which national planning and capacity building can take place. The successful delivery of these actions can then effectively complement the regional processes for establishing consensus on conservation priorities, standards, and strategies.

In the past, mostly because of the lack of political support, integration efforts have failed. Notwithstanding the obstacles, problems, and other forces in the Caribbean, there really is a great deal of functional cooperation being practiced daily, and fortunately, such interest in cooperation is growing. Within the next decade, it may well be the economic issues, especially those of fisheries and tourism, rather than political issues that effectively integrate the Wider Caribbean region. In combination with the economic issues, the promotion of the three basic essential linkages — physical, cultural, and institutional — will be an expedient way to integrate the philosophies and activities among countries. Along with that, the implementation and achievement of a comprehensive coastal zone management policy to preserve and protect the Caribbean's abundant marine resources will be essential.

Cuba: An island's approach to marine biodiversity

Diana Ibarzábal and Juan P. García, Institute of Oceanology

Translated from the Spanish by Alejandro duBouchet, Center for Marine Conservation.

Cuba is the largest island in the Wider Caribbean — 11,860 km^2 in area. It is rich in marine and terrestrial species, including a number of endemic forms, with a long history of scientific investigation. As in all countries, however, there is still need for more investigation. This article describes the key institutions involved in this ongoing discovery process. [D.E.M.]

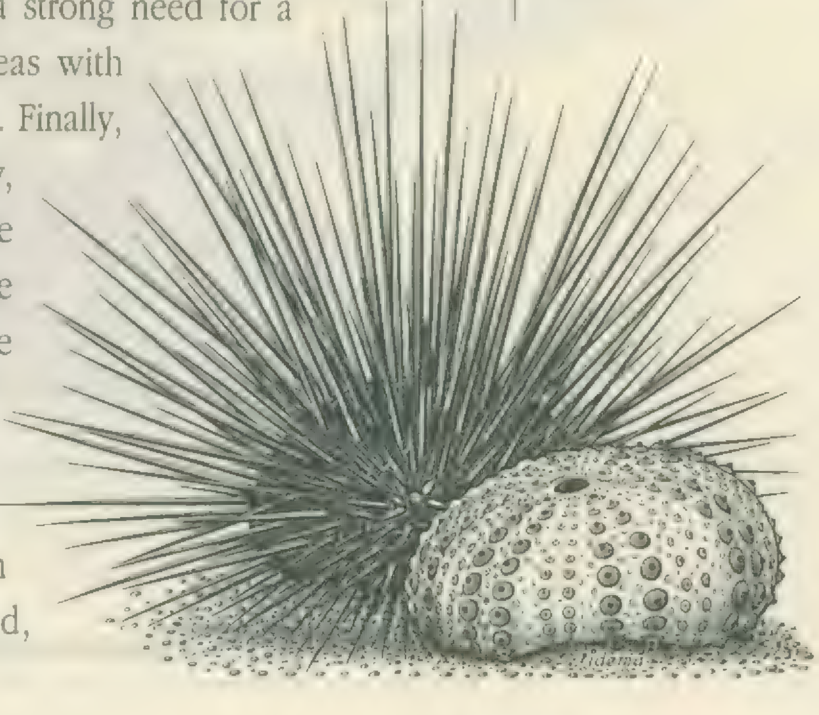
INTRODUCTION

No Caribbean country has yet achieved a comprehensive assessment of its marine biodiversity, so it is difficult to know how biodiversity is distributed within the Basin. Nonetheless, the data that are available for well known groups, such as fishes, imply that Cuba may be the custodian of the largest amount of marine biodiversity of any island country in the region. In any case, it is clear that Cuba occupies a critical position with respect to marine issues, because it is situated precisely where the Caribbean Sea, Atlantic Ocean, and Gulf of Mexico come together. Thus situated in the bottleneck, it is obvious that Cuba's marine resources are affected by activities in many of the surrounding countries, and that the quality of the Cuban marine environment will affect those countries in turn. It is partly for this reason that Cuba was among the first countries to sign the Convention on Biological Diversity.

ISSUES AND CONCERNS

Around the world, marine species and ecosystems are facing numerous threats. Cuba is no exception. For instance, all species of the phyllum Coelenterata (including rocky corals, black corals, and sea fans and their relatives) are listed as endangered due to sedimentation, pollution, vessel anchorages, human extraction, ecologically provoked disturbance, and algal invasion. The latter is due to massive mortality of the black sea urchin (*Diadema antillarum*) after 1983 due to an unidentified organism. And so, the list goes on.

Human activities are the main threat to non-commercial species, and the degree to which these species are affected depends on the site of their habitats. It is no surprise that areas being used for agriculture and industry near big cities and coastal zones are the most affected. Fortunately, most commercial species are protected by regulations. However, the system designed to survey and control the fishing of these species does not always guarantee fulfillment. Many species are furtively or illegally extracted, as in the case of the Antillean manatee (*Trichechus manatus*) and several marine reptiles, and this is a matter to be concerned about.



Black Sea urchin *(Diadema antillarum* Phillipi*)*

Given the unique features of the marine environment, the distribution of its inhabitants, and the ways in which they are exploited, several steps must be taken on a national level. Specific regulations for commercial and endangered species need to be strengthened and enforced, and there is a strong need for a system of protected areas with different levels of access. Finally, the study of the ecology, genetic diversity, and the potential economic value of Cuba's marine biodiversity must continue. So far Cuban marine diversity has been relatively well studied,

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Diana Ibarzábal and Juan Pablo García, Instituto de Oceanología, Avenida Primera numero 18406e/184 y 186, Reparto Flores, Ciudad de La Habana, 12100, Cuba, Tel: 537-21-0306, Fax: 21-33-8214, E-mail: <oceano@ceniai.cu>

though not in the same degree in all regions. Places such as the Golfo de Batabanó and the Archipiélago Sabana-Camagüey have been the object of higher attention, while little has been done in the coastal zones of eastern Cuba and the southeast and northwest regions of the country.

STRATEGIES FOR SUCCESS

In order to coordinate research on biodiversity resources and promote their sustainable use, Cuba established the National Center for Biodiversity (CENBIO) within its Ministry of Science, Technology, and the Environment. It includes a Node for Marine Biodiversity, which was established in the Ministry's Institute of Oceanology. The Node consists of a group of experts from all Cuban institutions engaged in research on marine topics. Its primary functions are:

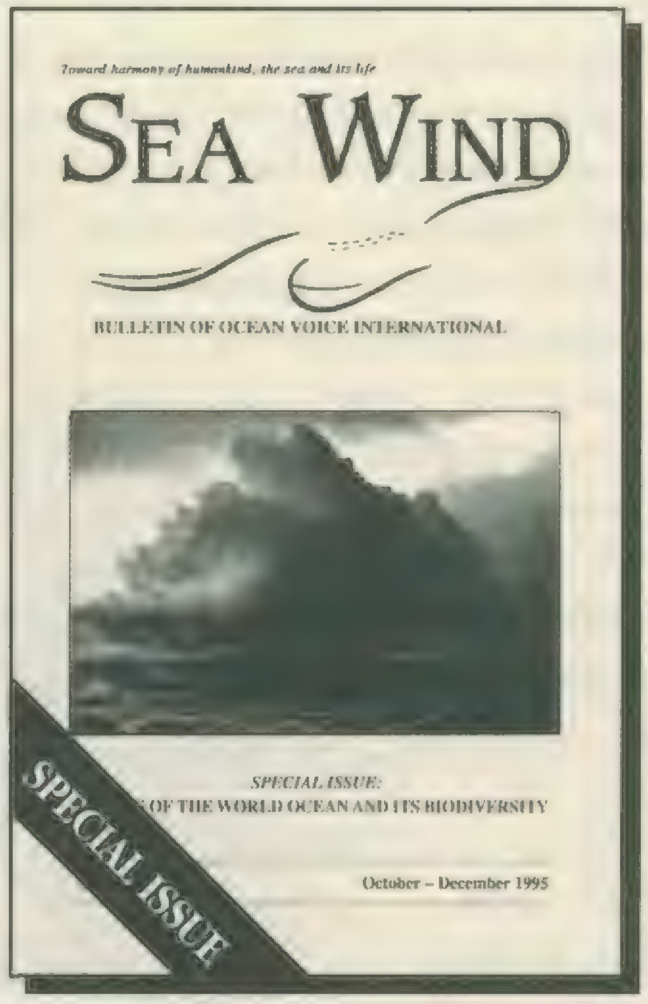
- To promote, coordinate, and give advice about the inventories and research related to the Cuban marine flora and fauna;
- To coordinate the development and maintenance of reference collections of marine biota and to promote the standardization of its databases;
- To promote and participate in the planning, organization, and management of coastal and marine protected areas; and
- To develop and coordinate a program for education on the marine environment.

Center of Natural Marine Collections

For 30 years, the Institute of Oceanology has carried out information gathering activities, including the acquisition of voucher specimens that document the country's marine biota. In 1995, these collections and data were consolidated in the new Center of Marine Natural Collections. The collections constitute the primary source of reference material for marine biodiversity studies in the northern Caribbean Basin, and they will be available to both Cuban and international systematists and researchers. The collections in fluid comprise more than 10,900 lots that include representatives of more than 1,800 species of fish, algae, higher plants, and invertebrates. Additional dry collections include gorgonaceans, sponges, decapods, and a herbarium.

A National Survey of Marine Biodiversity

During 1995, an important group of researchers from the main Cuban scientific institutions engaged in marine studies wrote "The National Survey of Marine Biodiversity," as part of the Cuban country study on biodiversity as obligated by ratifying the Convention on Biological Diverversity. The Survey will be published as a way to summarize and update the current knowledge about habitats, potential uses, conservation status, and threats to Cuban marine biodiversity. The Node for Marine Biodiversity will distribute the Survey so that decision makers, industries, business, educators, and researchers will better understand the importance of marine biodiversity.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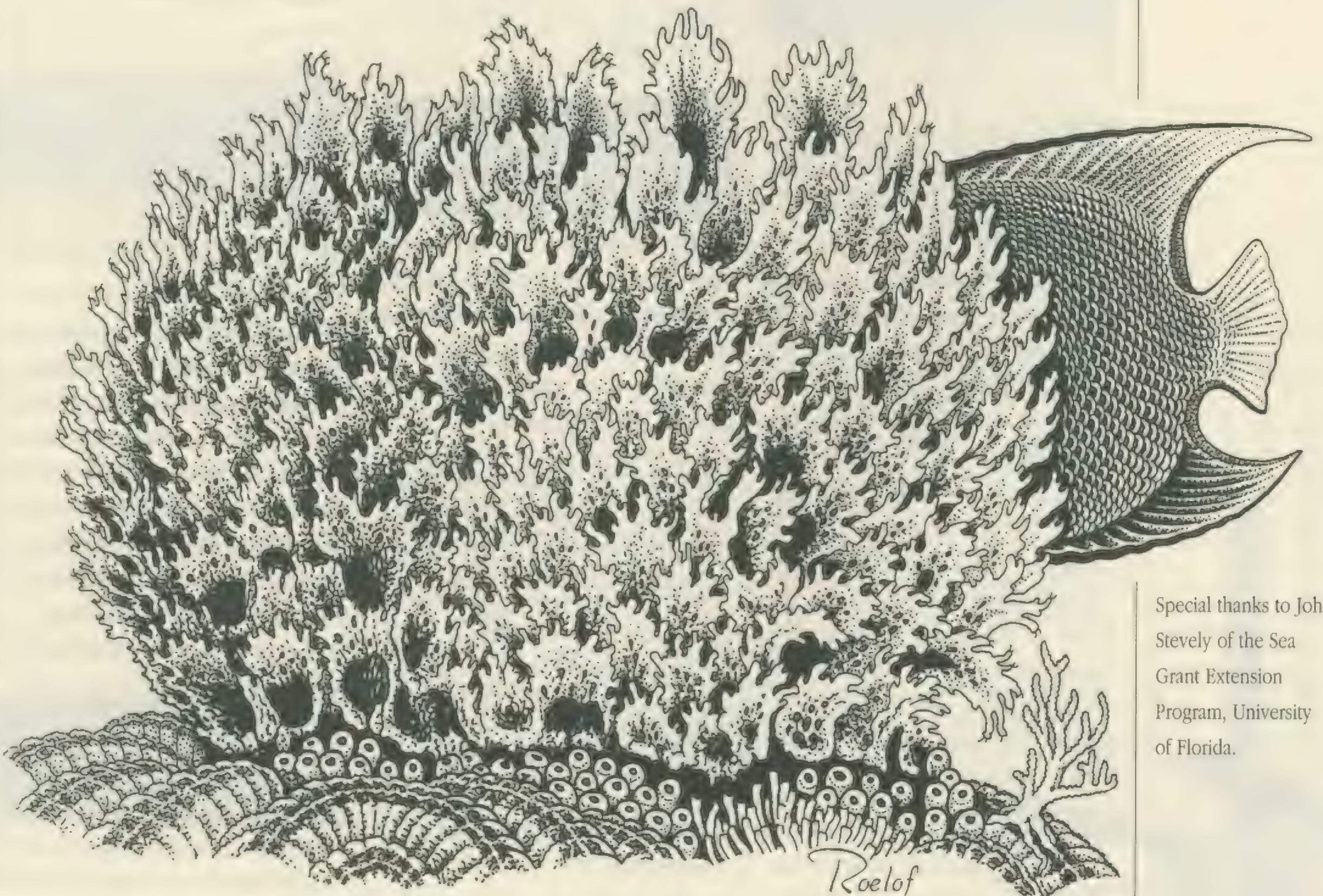
Hippospongia lachne

Two hundred out of the 400 species of sponges (phylum Porifera) of the Antillean Province have been identified in Cuba, the majority being in the Class Desmopongia. Sponges perform many functions in the coral reefs: they shelter the early stages and adults of numerous species, filter huge volumes of water, withholding the suspended organic matter, and in the geological past have contributed to rock formation on the reef. Boring (or perforating) sponges that bio-erode calcareous materials help to form sediment and to renew the coral reef. The species *Hippospongia lachne*, most commonly called sheepswool, is the most important commercial sponge; Cuba is a leader in its collection and export. Some sponges are potentially important for the drug industry, since they produce substances such as esterols, terpenoids, nucleosides, nucleic acids, bromopyrrolic compounds, dibromothyrosine derivatives, and benzoquinones that are biologically active. The main threats sponges face are increased sedimentation, changes in salinity, and excessive pollution.



Special thanks to John Stevely of the Sea Grant Extension Program, University of Florida.

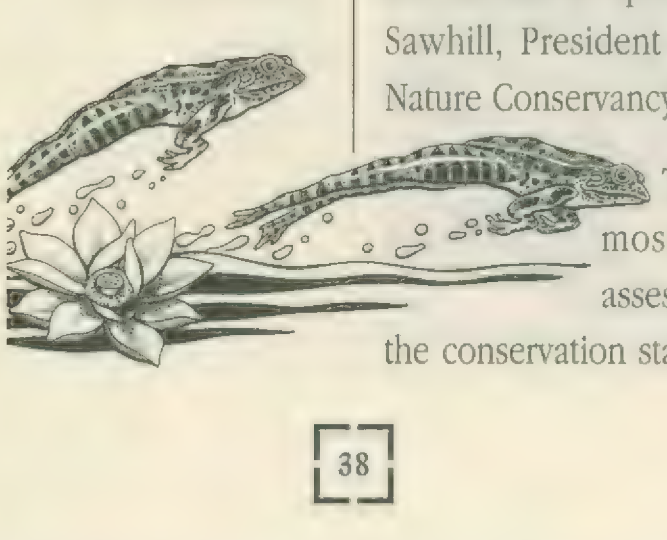
Biodiversity news

One third of US species at risk

The Nature Conservancy points out that species dependent on rivers, streams, and lakes are in particular trouble.

Nearly one third of plant and animal species are at risk in the United States, according to The Nature Conservancy's 1996 Species Report Card for US Plant and Animal Species. At least 101 US species are known to be extinct, while another 450 species are missing and feared extinct. Freshwater mussels, crayfish, fresh-water fish, and amphibians are the animal groups most at risk. Flowering plants also received low marks with 5,121 species, one third of known species, at risk. Mammals and birds were doing *relatively* well in comparison to these groups.

Of the 20,481 species examined, 1.3% are extinct or possibly extinct, 6.5% are critically imperiled, 8.9% are imperiled, and 15% are vulnerable. Species dependent on rivers, streams, and lakes are in particular trouble. This is due to continuing poor water quality and the long-term effect of dams and other water diversions. "These figures clearly show that efforts to protect the nation's water quality will not only benefit people, but also these species," said John C. Sawhill, President and CEO of The Nature Conservancy.



The report, the most comprehensive assessment to date on the conservation status of US species, reflects the work of more than 500 scientists from the Conservancy and the affiliated State Natural Heritage Centers. According to Sawhill, "We realize that, given limited resources, protection efforts must focus on the most significant species and ecosystems, where the greatest conservation effort will be achieved. This annual species report card allows us to base these focused efforts on solid science." [News Release, The Nature Conservancy, 2 January 1996]

Largest wetland in the world may not be drained after all!

Responding to local and international concerns, Mr. Marcelo Jardim, the president of a five-nation waterway commission, pledged not to drain the world's largest wetland, the Gran Pantanal of South America.

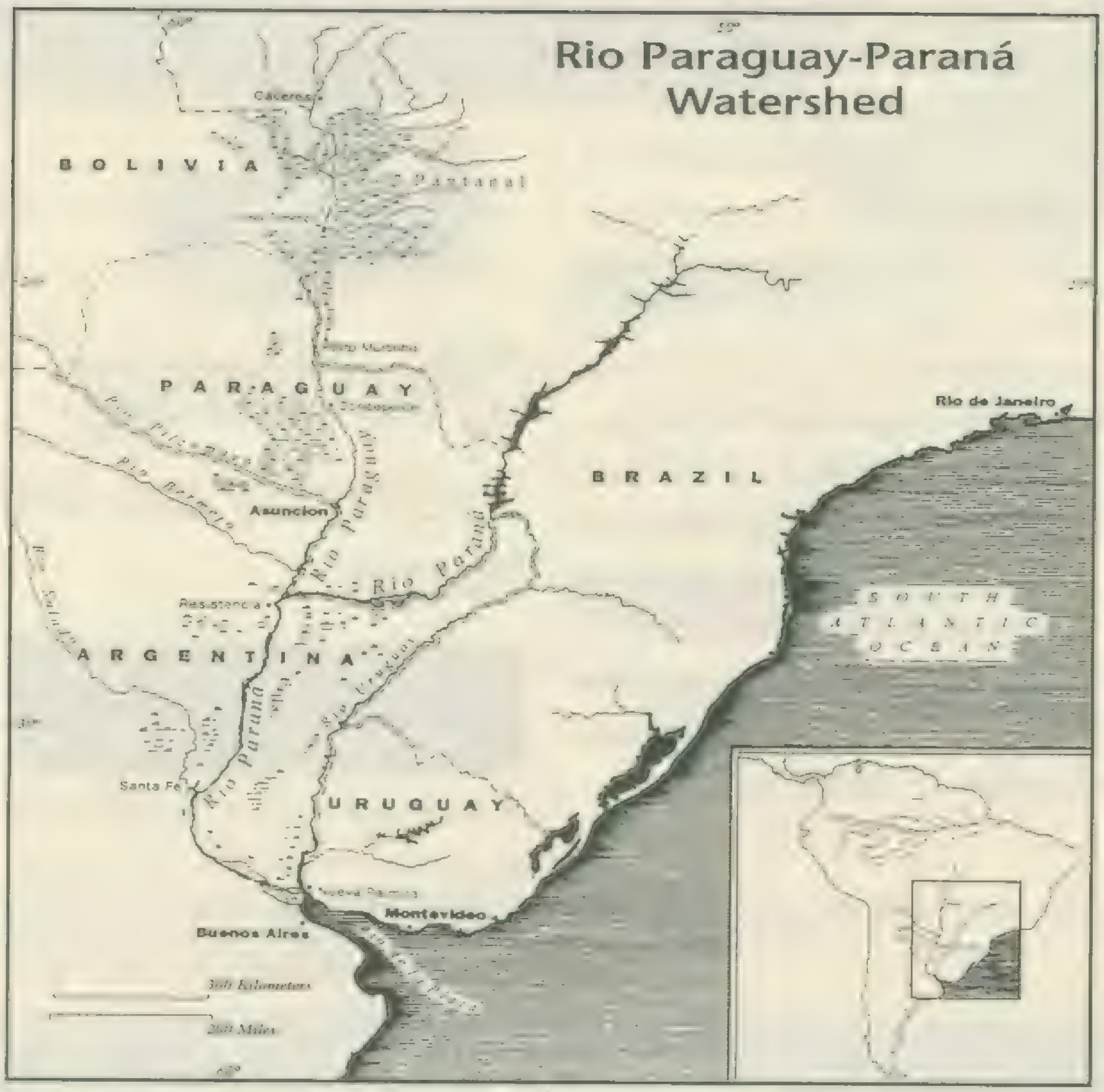
Speaking from his office in Buenos Aires, Mr. Jardim made the announcement to allay fears that the $1.3 billion inland shipping proposal, known as Hydrovia, would cause immense ecological damage. Many World Wildlife Fund Canada (WWFC) supporters wrote to protest the Hydrovia proposal. They helped raise awareness of the threats and put pressure on funding agencies for this massive project.

There will be no engineering works in the Pantanal. "Interventions...will [only] be based upon signs, buoys, communications improvements, and measures for navigation security, preserving the natural ecosystems," Mr. Jardim said.

But development of the Hydrovia waterway is not dead. There will still be some waterway development along the 3,500-kilometre Paraguay River, which flows southward from Brazil through Bolivia, Paraguay, Uruguay, and Argentina to the Atlantic Ocean. But Mr. Jardim has also pledged that the Hydrovia Commission will identify and avoid critical ecosystems along this route and involve the public in the environmental assessments as the project moves forward.

The Gran Pantanal — Portuguese for big swamp or wetland — harbours an extraordinary concentration of resident and migratory waterbirds in its flooded grasslands, wet savannahs, swamp forests, and meandering rivers. Up to 20 species of shorebirds that breed in the Canadian north migrate to and through the Pantanal, and along the Paraguay River system, to the southernmost shores of South America.

On behalf of the entire WWF international network, WWFC has accepted responsibility for monitoring the Hydrovia issue to ensure that the commitments to protection and public participation are honoured



The Gran Pantanal spans five countries in South America. Map courtesy of World Wildlife Fund Canada.

over the next year, while the environmental assessment is underway. [*Working for Wildlife*, Winter 1995, p. 1].

New address for Association of Systematics Collections

The Association of Systematics Collections has moved. Their new address is: Association of Systematics Collections/1725 K St. NW, Suite 601/Washington, DC 20006-1401/USA. Their new phone and fax numbers are (202) 835-9050 and (202) 835-7334, respectively. E-mail addresses are the same. Elaine Hoagland can be reached at: **<elaine@ascoll.org>**, and the ASC can be found on the WWW at: **<htpp://www.ascoll.org/>**.

Joining the global community—enhancing Southern Internet access

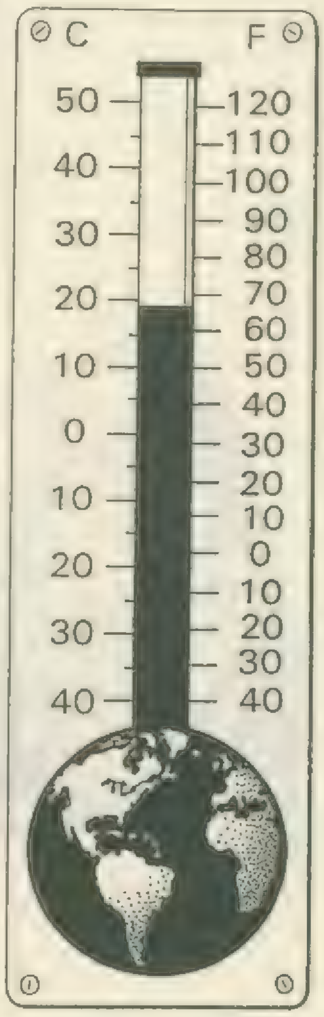
IDRC Reports for January 1996 contains several articles on Southern access to the Internet: "Moving Asia from Grassroots to Cyberspace" discusses the study by The Pan Asia Networking Program on the ability of Asian countries to access the Internet. PAN also facilitated the capacity of some groups to commu-nicate electronically. (PAN's URL is: **<http://pan.idrc. org.sg/pan>**.) Along the same lines "Connecting the Global Development Community — Bellanet" focuses on the IDRC-nurtured network as an electronic means of sharing ideas, exchanging information, and developing partnerships. A profile of Jai Haravu (who has 30 years of expertise in the information field) shows how his network helped the unemployed, peasants, and cultural organizations develop databases, manage libraries, and communicate among themselves. Two other articles are included: "Rising to the Information Challenge" and an article on the Elada 21 CD-ROM project called "Agenda 21 Goes Electronic."

These articles bespeak the benefits that can accrue at local levels from linking to the global commons and sharing wisdom with one another. The Internet provides access to a world of information, including contacts with individuals and organizations. Those excluded from this rich resource, especially those who cannot afford today's expensive journals, books, videos, and CD-ROMs, will fall behind in the conservation of biodiversity, sustainable use of its components, and the benefits that accrue from them. Internet access in Africa is said to be growing more rapidly than on most other continents, but there is much catch-up needed there and in other countries. This is especially true for those countries with poor telecommunication structures that lack the reliability and band-with of quality phone lines. [D.E.M.]

Scientists call for action on global warming

The world's leading panel of experts reports an increasing consensus of scientific opinion that global warming is caused in part by human activity. The Intergovernmental Panel on Climate Change (IPCC) recently released a draft report that includes some startling findings:

- global temperatures will likely increase by 0.8° to 4.6°C by 2100 A.D., changes that are more rapid than at any time during the last 10,000 years;
- floods and droughts will increase in frequency, affecting food production in the areas of sub-Saharan Africa and South Asia;
- there will be major losses of forest and mountain species, which cannot adapt fast enough to even the most optimistic of scenarios; and
- sea levels will rise between 0.1 and 0.8 metres, causing the loss of important coastal wetlands, beaches, and coral reefs.

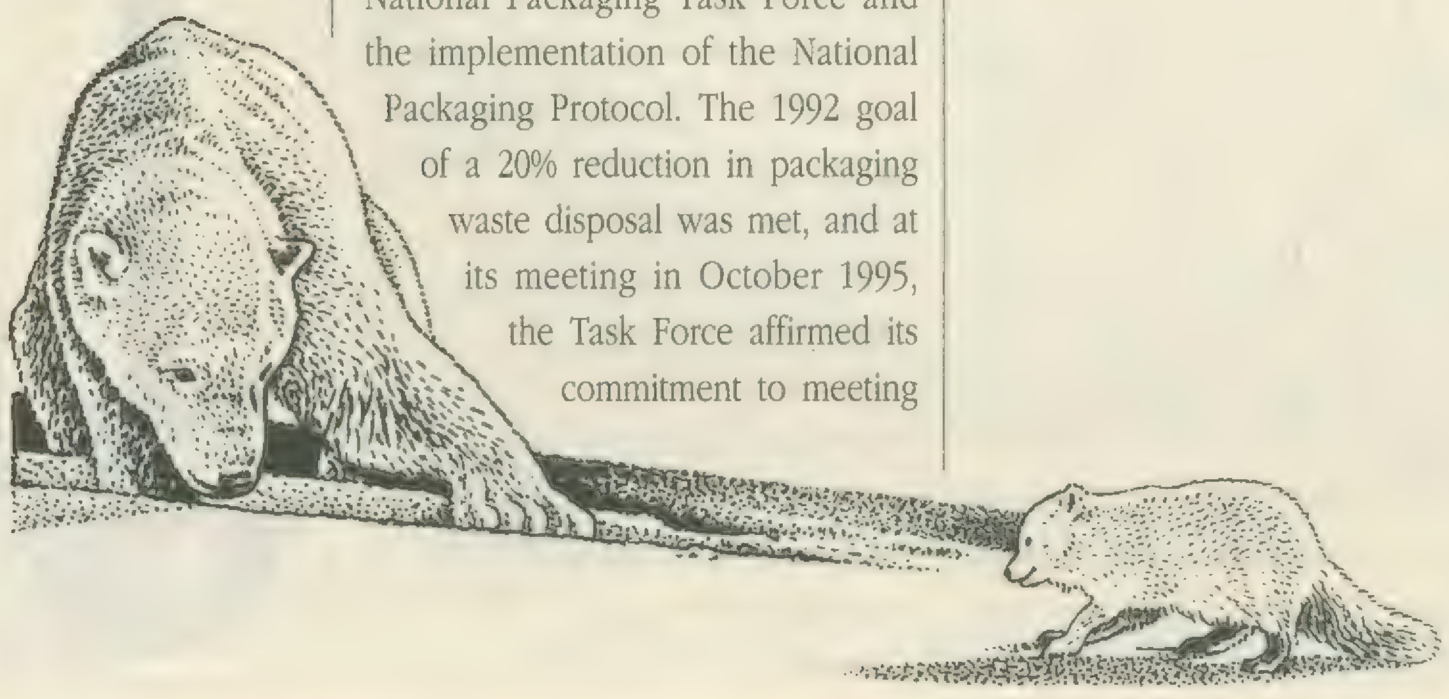


Although scientists are divided on the magnitude and speed of the projected changes, over three-quarters project large and negative impacts to the environment caused by the build-up of greenhouse gases. Waiting for greater scientific certainty regarding global climate change is reckless from both an environmental and an economic perspective.

The IPCC projects that *reductions* in emissions of carbon dioxide of over 60% are necessary to stop the pool of greenhouse gases from expanding. It calls for a range of immediate policies including: implementing carbon taxes; eliminating barriers to less carbon-intensive technology caused by vested interests; a review of existing investments in carbon-intensive products; stimu-lating institutional inertia; and promoting information about the global warming situation to both the public and private sectors. The motor vehicle industry provides one example of an industry where change is urgently required. [Condensed from *News from West Coast Environmental Law* Vol. 19:09, p. 1.]

Canada succeeds in reducing packaging

Canada is becoming a world leader in packaging and recycling industries, thanks largely to the partners of the National Packaging Task Force and the implementation of the National Packaging Protocol. The 1992 goal of a 20% reduction in packaging waste disposal was met, and at its meeting in October 1995, the Task Force affirmed its commitment to meeting the 1996 goal of a 35% reduction, with a 50% reduction by the year 2000. The Task Force identified a number of areas where specific action could be taken in the short term. These areas included development of material reduction strategies, expanding the development and application of LifeCycle Assessment (LCA) to product and packaging systems, and promoting the use of true-cost accounting for municipal solid waste management systems. [*Enviro Tipsheet* No. 101, Environment Canada]



Cyberdiversity:

Biodiversity and the Internet

ORCA's Internet Information Service

In an attempt to allow as many users as possible to access the coastal resource information it collects, organizes, and distributes, the Office of Coastal Ocean Resources Conservation and Assessment (ORCA) of the National Oceanic and Atmospheric Administration (NOAA) have developed the ORCA Internet Information Service — a multi-faceted World Wide Web site that can be reached using many common navigators including Cello, Lynx, Mosaic, and Netscape. Its URL is <**http://www-orca.nos.noaa.gov**>. Modem access is available by dialling (301) 713-4385.

What is ORCA and what does it do? ORCA is one of six offices within NOAA's National Ocean Service. It is made up of three divisions and one national centre, each dedicated to collecting and disseminating the information necessary for understanding and managing the nation's coastal areas. While these divisions typically work together, the information they collect and organize is thematically distinct, ranging from strategic, national, and regional assessments of coastal resources and uses, to detailed information on chemical contamination of shellfish tissues and sediments. ORCA also is responsible for assessing and responding to spills of oil and hazardous materials along the coast and for investigating the damages resulting from these releases, determining the cost of restoration, and ensuring that affected natural resources are restored.

What does the ORCA Internet Information Service do?

Operating through a point-and-click interface, the service allows users to search ORCA's corporate database of coastal resource products and services to get information about the organization, explore links to sites detailing specific projects, order and/or download from among over 500 related publications and data sets, and access products on-line. A "What's New" page allows users to browse through the most recent offerings, and access utilities allow the corporate database to be searched by data type, geographic scope, topic, ORCA unit, and time frame. Users can also provide ORCA staff with e-mail comments on the content and structure of the system.

What is available on the system relative to biodiversity?

The service contains specific data related to species biodiversity, organized both as downloadable publications and on-line data sets. Two major examples of this information are the selected data sets available from the Nation Status and Trends (NS&T) Program of Environmental Quality and the Estuarine Living Marine Resources (ELMR) Program.

NS&T Program: Since 1984, the NS&T Program has monitored the spatial and temporal trends of chemical contamination in biological resources and their responses to that contamination on a national scale. Contamination trends over time are monitored through the program for over 200 sites throughout the coastal United States. Once users are in the ORCA Service, many of the data collected by the NS&T Program are available, organized as structured query language (SQL) tables that can be downloaded for later use. Example data sets include site locations of benthic surveillance and tissue chemistry with regards to accumulated metals and organic materials such as pesticides, PCBs, and polyaromatic hydrocarbons (PAHs).

ELMR Program: The ELMR data included examines the distribution and relative abundance of fishes and invertebrates throughout the coastal United States. The information is organized regionally, and hard-copy reports summarizing the information have been completed for the North, Middle, and South Atlantic, the Gulf of Mexico, and West Coast regions. Life history information is also available for species on the West Coast, and will soon be available for species in the Gulf of Mexico region as well. While all ELMR data will eventually be available electronically, users may now either request the hard copy reports or use an application such as Adobe Acrobat to view and browse the reports for Gulf of Mexico and West Coast estuaries.

What other coastal resource data is available?

Other coastal information is available on a variety of subjects, ranging from demographic data such as human population growth and coastal development to regional and national environmental data such as ORCA's inventory of agricultural pesticide use in coastal areas. Users also have access to a complete office publications listing, including short abstracts of each document, and can download a variety of these products for browsing and printing.

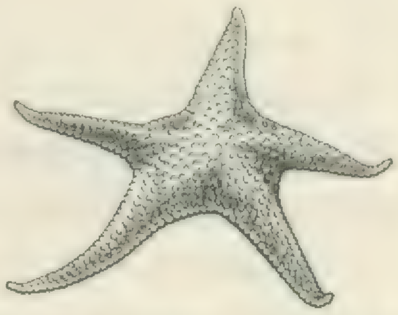
How does this relate to ORCA's GIS capabilities?

All coastal and estuarine data collected by the office is organized within a Coastal Assessment Framework (CAF) — a set of US drainage areas that have been digitized to make delineating the location and abundance of regional features more precise. All of ORCA's digital CAF boundary files are available through the service, as are the files for the office's national medium-resolution (1:70,000) shoreline. Other geographic information is provided on specific topics such as NOAA's digital bathymetry database and benthic maps of bottom habitats within the Florida Keys National Marine Sanctuary. When users download any of this information, it can be directly imported into a geographic information system using ArcInfo or other software.

What related technologies are available on-line?

The service also provides links to QuickTime video clips from a recently released ORCA CD-ROM, as well as information on how it can be ordered. Released on Earth Day 1995, and designed for the general public, *Turning the Tide: America's Coasts at a Crossroads* is an educational product that illustrates some of the uses, functions, and ways of managing coastal areas. It is currently being used by the Smithsonian Institution's National Museum of Natural History as part of its exhibit, "Ocean Planet."

A second ORCA CD-ROM, examining analysis and planning for integrated coastal management, has recently been released to test the use of multimedia as a means of communicating the new concepts and tools related to this topic. Similar video clips and ordering capabilities will be available on-line in the near future. [Charles Ehler, Director, ORCA/NOAA, (301) 713-2989, ext. 127.]



Biodiversity meetings

10–13 JULY 1996
National Conference of the Australian Marine Sciences Association (AMSA 96), to be held in Hobart, Australia.

Contact: AMSA 96, Mures Convention Management, Victoria Dock, Hobart Tasmania 7000 Australia, Tel: 61 (0)02 341 424; Fax: 61 (0)02 344 464; E-mail: <mures@hba.trumpet.com.au> WWW: <http://www.utas.edu.au/conf.html>

10–13 JULY 1996
5th Symposio de Botanica, to be held in La Habana, Cuba.

Contact: Carlos Zavaro Perez, Dpto. Plantas Vasculares, Instituto de Ecologica y Systematica, Carretera de Varona, Km. 31/2, C.P. 10800, A.P. 8010, Boyeres, Ciudad de La Habana, Cuba, Tel: 537 333758; Fax: 537 331325; E-mail: <ecologia@cenial.cu>

14–18 JULY 1996
International Congress on the Biology of Fishes, to be held in San Francisco, California, USA.

Contact: Don MacKinlay, Fisheries and Oceans, 555 West Hastings St., Vancouver, BC, Canada V6B 5G3, Tel: (604) 666-3520; Fax: (604) 666-3450

22–26 JULY1996
7th International Conference on Statistical and Mathematical Models in Environmental Sciences, to be held in Sao Paulo, Brazil.

Contact: Ines Iwashita, (IEA/USP), Universidade de Sao Paulo, USP, Sao Paulo, Brazil, 05508-900, Tel: 5511 818-4442/3919; Fax: 5511 818-4306 211-9563; E-mail: <cpereira@ime.usp.br>, WWW: <http://www.ime.usp.br/~cpereira/index.html>

28 JULY–2 AUGUST 1996
Second World Fisheries Congress on Developing and Sustaining World Fisheries Resources: The State of Science and Management, to be held in Brisbane, Queensland, Australia.

Contact: Second World Fisheries Congress, P.O. Box 1280, Milton Brisbane, Queensland 4064, Australia Tel: (+617) 3369 0477; Fax: (+617) 3369 1512; E-mail: <fish96@sunray.im.com.au>

29 JULY–3 AUGUST 1996
VI Symposium of the International Organization of Plant Biosystematists, to be held in Tromso, Norway.

Contact: International Organization of Plant Biosystematists,Hugo de Vries Laboratory, University of Amsterdam, Kruislaan 318, 1098 SM Amsterdam, The Netherlands, Tel: 31 20 525 7600; Fax: 31 20 525 7622

11–15 AUGUST 1996
Ecological Society of America Meeting, to be held in Providence, Rhode Island, USA.

Contact: Ecological Society of America, #400, 2010 Massachusetts Ave. NW, Washington DC, USA 20036 Tel: (202) 833-8773; Fax: (202) 833-8775

12–17 AUGUST 1996
Coastal Zone Canada 96, to be held in Halifax, Nova Scotia, Canada.

Contact: Mohammed El-Sabh, CZC 96 Conference Chair, Departement d'Oceanographie, Université du Québec à Rimouski, 300 des Urslines Rimouski, Quebec,G5L 3A1 Canada Tel: (418) 724-1707 Fax: (418) 724-1842 E-mail: <mohammed_el_sabh@uqar.uquebec.ca>

13–16 AUGUST 1996
Pacific Ocean Remote Sensing Conference: Ocean Science and Probing, to be held in Sidney, Britsh Columbia, Canada.

Contact: Jim Gower, PORSEC 96, Inst. of Ocean Sciences, P.O. Box 6000, Sidney, BC Canada, V8L 4B2, Tel: (604) 363 6558; Fax: (604) 363 6479; E-mail: <gower@ios.bc.ca>

19–23 AUGUST 1996
WOCE (World Ocean Circulation Experiment) Pacific Workshop, to be held in Newport Beach, California, USA.

Contact: Sasha Walters, US WOCE Office, 305 Arguello Drive, College Station, Texas, USA 77840, Tel: (409) 845-1443 Fax: (409) 845-0888, E-mail: <swalters@astra.tamu.edu>, WWW: <http://www-ocean.tamu.edu/WOCE/uswoce.html>

20–24 AUGUST 1996
Second World Congress on the Preservation and Conservation of Natural History Collections, to be held in Cambridge, UK.

Contact: Administrator, 2nd World Congress, Department of Earth Sciences, University of Cambridge, Madingly Rd., Cambridge, UK CB3 0EZ, Fax: 01223 60799

22–25 AUGUST 1996
Annual Meeting of the Conservation Breeding Specialist Group of the IUCN Species Survival Commission, to be held in Denver, Colorado, USA.

Contact: Debra Horvath, CBSG, Registration, Denver Zoo, 2300 Steele Street, Denver, CO, USA 80205-4899 Tel: (303) 331-5810

25–29 AUGUST 1996
Sustainable Fisheries: Economics, Ecology, and Ethics: Annual Meeting of the American Fisheries Society (AFS), to be held in Dearborn, Michigan, USA.

Contact: Neal R. Foster, President, IFS-AFS, National Biological Service Great Lakes Science Center, 1451 Green Road Ann Arbor, MI, USA 48105-2807; Tel: (313) 994-3331 ext. 264; Fax: (313) 994-8780; E-mail (preferred): <neal_foster@nbs.gov> or <nealfost@umich.edu>

25–31 AUGUST 1996

20th International Congress of Entomology, to be held in Florence, Italy.

Contact: Organizing Secretariat OIC, Via A. La Marmora 24, Florence 50121, Italy, Fax: 39-55-5001912

2–6 SEPTEMBER 1996

Fifth International Congress of Ethnobiology, to be held in Nairobi, Kenya.

Contact: Christine Kabuye, National Museums of Kenya, P.O. Box 45166, Nairobi, Kenya, Fax: 254 2 741424

4–9 SEPTEMBER 1996

The Biology, Ecology and Biotechnology of Thermophilic Microorganisms, to be held in Athens, Georgia, USA.

Contact: L. Bradham, Center for Biological Resource Recovery, Dept. of Biochemistry and Molecular Biology, Life Sciences Bldg., The University of Georgia, Athens, GA, USA 30602-7229, E-mail: <adamsm@bscr.uga.edu>

7–11 SEPTEMBER 1996

The Third International Congress on Education in Botanic Gardens, to be held in New York, New York USA.

Contact: Lucy Jones, Third International Congress on Education in Botanic Gardens, Brooklyn Botanic Garden, 100 Washington Avenue, Brooklyn, NY, USA, 11225-1099

24–27 SEPTEMBER 1996

Eastern Pacific Oceanic Conference, to be held in Mt. Hood, Oregon, USA.

Contact: Bill Peterson, NOAA / National Marine Fisheries Service, Marine Science Center, 2030 Marine Science Drive, Newport, OR, USA 97365, Tel: (541) 867-0201 Fax: (541) 867-0389, E-mail: <petersbi@ccmail.orst.edu>

5–12 OCTOBER 1996

Conservation of the Biological Diversity as a Prerequisite for Sustainable Development in the Black Sea Region, to be held in Tbilissi/Batumi, Republic of Georgia.

Contact: Workshop "Black Sea Region" Heinrich Schmauder, Federal Agency, for Nature Conservation, Konstantinstr.110, D-53179 Bonn, Germany, Tel: 49-228-8491-176; Fax: 49-228-8491-200; E-mail: <1003154.2714@compuserve.com>

14–23 OCTOBER 1996

IUCN General Assembly (World Conservation Congress), to be held in Montreal, Quebec, Canada.

Contact: IUCN, Rue Mauverny 28, CH-1196 Gland, Switzerland, Tel: 4122 999 0001; Fax: 4122 999 0002

28–29 OCTOBER 1996

International Symposium on Assessment and Status of Pacific Rim Salmonid Stocks, to be held in Sapporo, Hokkaido, Japan.

Contact: Hisashi Endo, NPAFC Secretariat, 6640 Northwest Marine Drive, Vancouver, BC, Canada V6T 1X2, Tel: (604) 228-1128; Fax: (604) 228-1135; E-mail: <endo@unixg.ubc.ca>

21–23 NOVEMBER 1996

Mote International Symposium on Marine Stock Enhancement: A New Perspective, to be held in Sarasota, Florida, USA.

Contact: Felicia Coleman, Ph.D., Mote Symposium, Center for Professional Development, Florida State University, Tallahassee, Florida, USA 32306-2027, Tel: (904) 644-2019 Fax: (904) 644-9829; E-mail: <coleman@bio.fsu.edu>, For auto-matic reply: <slampman@ mailer. fsu.edu> (Put "Mote Symposium" on the topic line)

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Book and periodical niche

Understanding marine biodiversity: A research agenda for the nation

By the Committee on Biological Diversity in Marine Ecosystems, National Research Council of USA. 1995. National Academy Press, 2101 Constitution Avenue NW, Washington, D.C. 20418, USA. 114 pp. Hardcover, ISBN 0-309-05225-4. US $29.95 (plus postage: $4 for first copy and $0.50 for each additional one).

The bay scallop industry of southern New England suffered its final demise in the late 1980s due to a series of brown tides. The dominant organism that caused the brown tides was a marine microorganism that no-one had ever seen. It came to the attention of the world, and received its genus and species names, only at the same time that it caused the collapse of an industry and the loss of a traditional way of life that had been associated with it.

Such a story is not uncommon in the marine world. It has been repeated with other fisheries and other unknown planktonic organisms in a number of major estuarine fish kills. The basic state of knowledge of marine biodiversity is so poor that we frequently become aware of new species only at the moment when they have a direct impact on human welfare. At such a moment, it would be desirable to have some knowledge of an organism's natural history, its ecology, and the factors to which it might respond, because such knowledge is the basis for possible intervention. Unfortunately, we can't manage a species when we don't even know what it is.

As modifications to the marine environment become more extensive, scientists are called upon by policy-makers and the public to predict the consequences of a proposed intervention or a possible alteration to habitat. Without an adequate basis in knowledge of marine biodiversity, scientists often find that they can only be reactive. They can tell what happened, as in the case of the New England bay scallop industry, but their role in the biodiversity crisis should be to say what will happen.

By the beginning of the 1990s, several US government agencies and research institutions recognized that marine biodiversity had become a critical issue with direct consequences for national welfare. They initiated a process to develop a national strategy for marine research that culminated in the report *Understanding Marine Biodiversity*. The primary means of gathering and evaluating information was a workshop entitled Biological Diversity in Marine Systems, which was attended by 54 marine scientists and held in Irvine, California, on 24–26 May 1994. The goals of the workshop were "to develop a well defined set of research questions designed to improve understanding of the causes and consequences of changes in marine biodiversity due to human activities, and to provide the knowledge and criteria for assessing and predicting subsequent effects of human stresses on the marine environment."

For most readers, a primary value of the report will be its comprehensive review of the issues associated with marine biodiversity and the thorough documentation provided in a bibliography of 400 references. Each issue is taken up in a brief discussion that puts it in a social or economic context and provides a current consensus on important factors affecting the topic. Case studies are given in boxes distributed through the text. Because the treatments are short and delivered in plain language, it is easy to quickly grasp the most significant aspect of each of the major problems to be dealt with in marine conservation.

The general goal of the report is to outline a national research agenda on biodiversity in marine systems, and this is accomplished partly through a set of research questions. The questions posed clearly arise from the research tradition in the United States and they reflect the trajectory of US institutions. While they might therefore be found by others to be culturally limited, the process was fruitful, and other countries may want consider starting with a similar approach.

The research agenda itself proposes a fundamental change in the way that biodiversity is measured and studied in the sea. The committee recommends the use of "integrated regional-scale strategies" that would coordinate programs at multiple sites within a large geographic area. The approach is intended to address the fact that marine systems are both large and open in nature. Both effectiveness and social relevance will require that separate marine research programs will contribute a larger strategy for understanding the marine world.

Michael L. Smith, Center for Marine Conservation, Washington, D.C.

Sylvia Earle (Photo by Al Giddings, © 1995.)

Sea change. A message of the oceans

Sylvia A. Earle. 1995. G.P. Putnam's Sons, New York. 361pp. Cloth ISBN 0-399-14060-3. US $ 25.95.

Although this book falls within the realm of popular science, any person actively involved in marine conservation, underwater technology, fisheries assessment, or other issues related to the sea will find it an important source of information. The credentials of the author (scientist, underwater explorer, scientific consultant, founder of an ocean engineering firm, policy maker, active conservationist) make possible the compilation of a great amount of high quality anecdotal and scientific information. The book has 17 chapters, contained in three parts — Sea of Eden; Paradise Lost; and Sea Change — with an appendix summarizing worldwide marine protected areas, and the US National Marine Sanctuaries. A list of 190 references directs reader to other sources of information related to sea research, exploration and conservation. Fifty-four black-and-white photographs illustrate Earle's most interesting moments of the book. The book brings a central message: the major importance of the sea (as a whole) to life on Earth and humankind, and the changes that are taking place in its quality. The text, written in a gracious manner with beautiful literary language, is provided like a tasteful mixed cocktail of personal adventure and scientific analysis.

From the very first chapter, the author raises questions about the importance of the sea to life on Earth, and the lack of attention to deep-sea exploration and investigation relative to that dedicated to air and space. With this in mind, Dr. Earle takes the reader on a marvelous journey to the Florida coasts, the Gulf of Mexico, the Bahamas, Hawaii, the Indian Ocean, Alaska, the Persian Gulf, and many other places.

No matter what your interests are, you will be magically trapped within the poetic moments of her life and the scientific analysis that combine to illustrate the "message of the oceans" of the "changes" that are taking place in the sea. Topics range from the behaviour of humpback whales (after three months of underwater observations and recordings in the open blue ocean off Hawaii), the impact of major oil spills on coastal ecosystems (the clean-up of the 250,000 barrels of crude oil that flowed into the Prince William Sound from the tanker *Exxon Valdez*, in Alaska, and the environmental impact of the Persian Gulf oil-well spills during the Gulf War), to the non-real theoretical assumption that the populations where fisheries are being exploited somehow live in isolation from other ecosystem elements, which are actually modified when the number of target species declines.

The author's 6,000 hours of underwater investigation and exploration include a 1,250-foot deep plunge off Hawaii with Jim, "the submersible you can wear," and a comprehensive study of marine benthic algae of Eastern Gulf of Mexico.

A 15-chapter journey takes the reader to dozens of places where the wonder, use, and vulnerability of the sea are demonstrated. Suggestions for healing some of the most common effects on marine ecosystems (pollution, coastal development, over-fishing) follow. The establishment of US marine sanctuaries is recreated through the well-known case of the Florida Bay-Florida Keys. The value of fisheries reserves is recognized, while noting the efforts of non-governmental organizations (such as the Center for Marine Conservation, and The Nature Conservancy) and other academic institutions. Some important issues presented include the comprehensive protection of fish populations and their habitat; differences in budgets for marine parks and terrestrial parks; the challenge of land versus sea properties; the size determination for parks; the commercial fishery conflicts; the link between the decline of reefs to the overload of chemicals and toxics due to runoff.

I would recommend this book to high-school students, marine scientists, and conservationists. All of them will get a wonderful sense of pleasure from it.

As the titles states, the sea is changing and the ocean is giving us a clear message. Something has to be done, and books like *Sea Change. A Message of the Oceans* raise awareness and motivate real action for its conservation.

"There is plenty of water in the universe without life, but nowhere is there life without water...and...this is a planet dominated by saltwater!"

Georgina Bustamante, Ph.D., The Nature Conservancy

Biodiversity news. The Smithsonian MAB Program

SI/MAB Biodiversity Program, International Center, Smithsonian Institution, Suite 3123, 1100 Jefferson Drive S.W., Washington, D.C., United States 20560. Tel: (202) 357-4793; Fax: (202) 786-2557; E-mail: <ic.simab@ic.si.edu>

This newsletter, according to its editors, informs a wide audience of SI/MAB's progress, discusses natural resource management techniques to the benefit of decision-makers in many countries, and describes resource management problems and solutions employed by individuals and agencies of different nations.

The Spring/Summer 1995 issue, Number 4, describes the SI/MAB Biodiversity Program; contains a message from Dr. Thomas E. Lovejoy and a report from the projects director, Francisco Dallmeier; tells about the Kejimkujik National Park cooperative research in eastern Canada; describes biodiversity plots in British Columbia in western Canada; tells about Cuba's Punta Gavilanes, Savskill, one of Africa's savannas; forestry efforts in China and Paraguay; and SI/MAB's second international course in biodiversity measuring and monitoring. Other articles involve quantitative ethnobotany in Beni; and biodiversity monitoring plots in China, Peru, Venezuela, Puerto Rico, and Guyana. And there is more!

Biodiversity News provides a good series of snapshots of biodiversity monitoring, especially in forests, and related topics. Contact the program at the above address for more information. [D.E.M.].

Biological systematics: The state of the art

By A. Minelli, Chapman & Hall, 1993. 387 pp. ISBN 0-412-36440-9.

This book presents a close look at the overall state of biodiversity, which is of great relevance at a time when "biodiversity" seems to be a word commonly heard in non-scientific communities in many countries. At the same time, scientists from these same countries lament financial cutbacks that limit research and the decline in number of new people entering the field of systematics, crucial to understanding biodiversity. Minelli, while not having the answers to all these problems, gives a comprehensive overview of the progress — and lack of progress — in our understanding of the relationships of all living organisms. As it encompasses so large a subject, the book is necessarily an overview and deals mainly with higher level taxa — but Minelli has researched it well.

The first five chapters make up Part 1 of this book, which tackles the concepts used in the field of systematics, from the concept of character coding for phylogenetic analysis to the concept of a species. It is difficult to identify the intended audience for this part of the book. Some terms are defined (e.g. sympatry, p. 48) and others are not (thelytoky, p. 77); some taxa are identified only by common name. A few other elements of the writing style caused slight interference in the flow of reading and comprehension of Part 1, which could have benefited from more editing. This may make the book less helpful for readers new to the field of systematics, while those already in the field could easily skip Part 1.

The most interesting section is Part 2, that which poses the question, "How many species do we know?" and provides an answer by analysis of data. In short, it is an overview of the state of phylogenetic knowledge of all higher taxa of living organisms, in an inventory of natural diversity. This section is a fascinating glimpse into all the organisms we forget or ignore as we become more specialized. Many alternative views on relationships are presented in this part, and the reader is given references for further reading on them all. At least one part of the schemes of relationship, that of fishes, has changed (Nelson, 1984; 1994), emphasizing some of the instability in classification and number of species that Minelli mentions. In a later chapter, Minelli has also turned to colleagues familiar with different taxa for their input on these taxa. In summarizing methods of predicting biodiversity numbers, Minelli comes to the very sensible conclusion that because of the non-standard size of lower groups (e.g. genera) within high taxonomic groups, there is an inherent problem comparing numbers of taxa across diverse groups in order to present such an estimate of diversity.

Throughout both Parts 1 and 2 there are many references to current research. A remarkable proportion of the book is made up of appendixes (23 in all), references, and 3 indexes (173 pages). Most of the appendixes and much of one index are classifications of various taxa. The points being made here are summarized more efficiently in the appropriate text sections.

Problems of funding and lack of resources (especially people) plague all areas of systematics and institutions throughout the world. The state of the art may appear to be in a shambles, but progress, while slow, *is* being made in this important field.

Alison M. Murray and Brian W. Coad, Canadian Museum of Nature

A Landmark in Science Publishing

Global Biodiversity Assessment
Editor
V.H. Heywood
University of Reading
Chair of the Assessment:
Robert T. Watson
Foreword by
Elizabeth Dowdeswell

The Global Biodiversity Assessment represents an unparalleled attempt to provide an independent scientific analysis of the current issues surrounding the importance of biodiversity. Over 1,000 leading scientists from around the world have contributed to the *Assessment,* providing an unprecedented source of information for decision-makers, officials, scientists and others interested in the future of the planet.

1995/1152 pp./121 line diagrams/184 tables
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Global Biodiversity Assessment
Summary for Policy Makers
Editor
V.H. Heywood
University of Reading

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–The Washington Post

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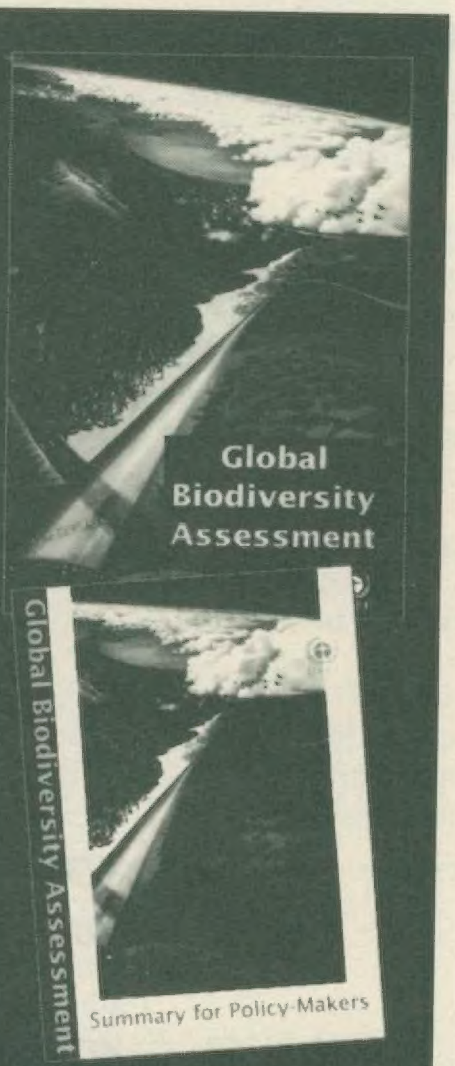
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...continued from page 2

regional approach is described by the Caribbean scientist José Ottenwalder. As an example of what is being done in one tropical island nation, Diana Ibarzábal and Juan Pablo García describe environmental initiatives in Cuba.

The basic themes of conservation on the continents were laid down about 150 years ago. For my part, I find many of them in the essays of Thoreau, but others might see earlier sources. By comparison, marine conservation — that is, an ethic based on thinking about the oceans rather than just extrapolating continental conservation to the seas — is perhaps as little as 15 years old. The essential first step is to make people aware of their effects on the marine environment, and to establish that humanity has attained the capacity, through technology or perhaps through sheer human biomass, to irreversibly change the sea.

Michael L. Smith

Michael L. Smith
Senior Research Scientist
Center for Marine Conservation
1725 DeSales St.
Washington D.C. 20036
Tel.: (202) 429-5609
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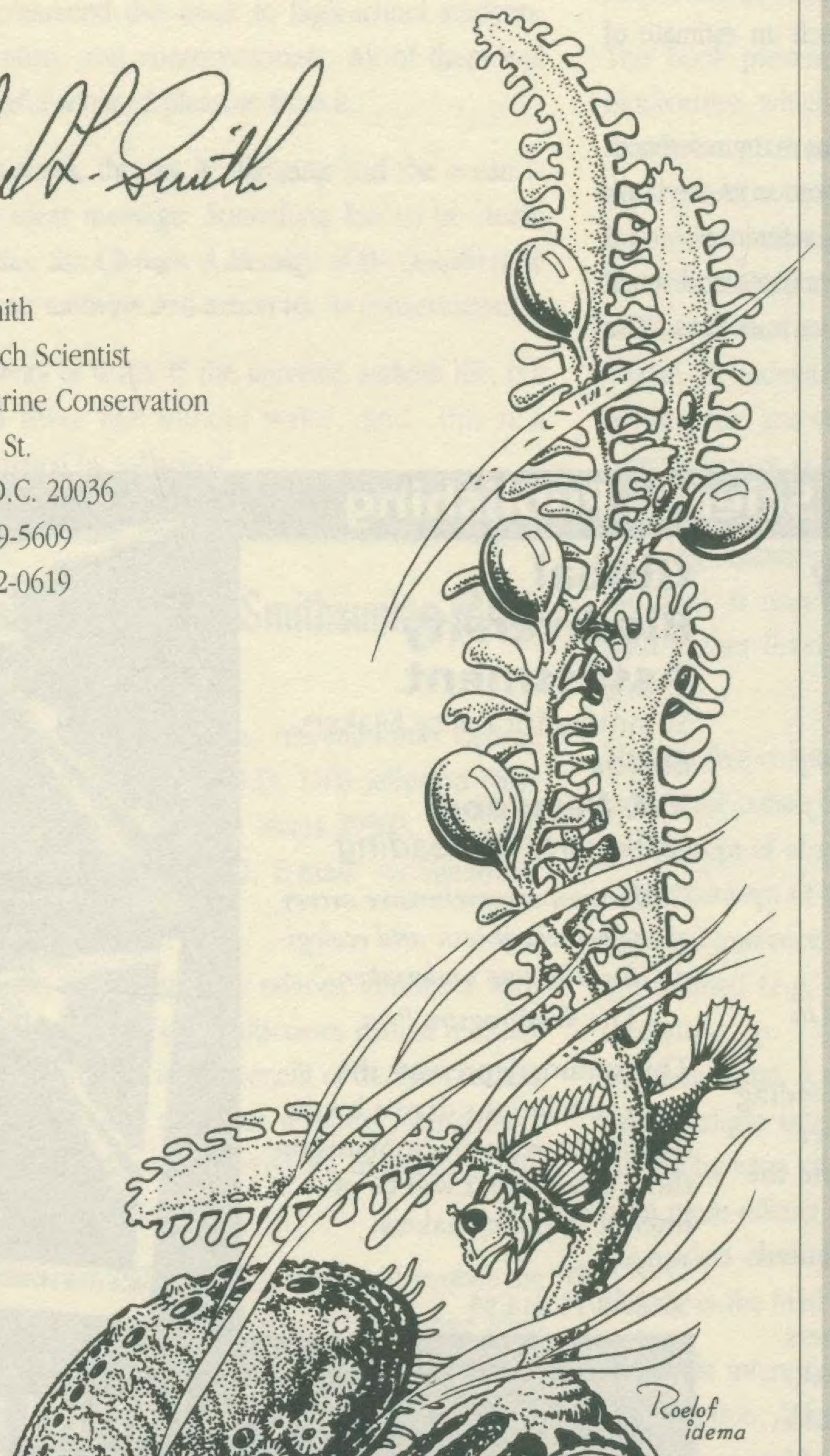

A few words about the Canadian Museum of Nature

The Canadian Museum of Nature (CMN) has its origins in the Geological Survey of Canada. Over 150 years later, the CMN has some 8 million specimens in its collection, which still represents only half the known species in this country, and an active team of scientists, collection managers, education specialists, and business experts.

The CMN's mandate is to increase knowledge and understanding of, appreciation and respect for, and interest in the natural world. This role has never been more crucial, as the demand for environmental harmony between the world's burgeoning human population and nature reaches a critical point. Scientifically, the Museum is developing research in three main areas: the Arctic in Peril, the Crisis in Biodiversity, and Origins of Modern Problems. For more information about the Museum's activities, please contact Karen Hahn, Corporate Communications at (613) 990-6273.

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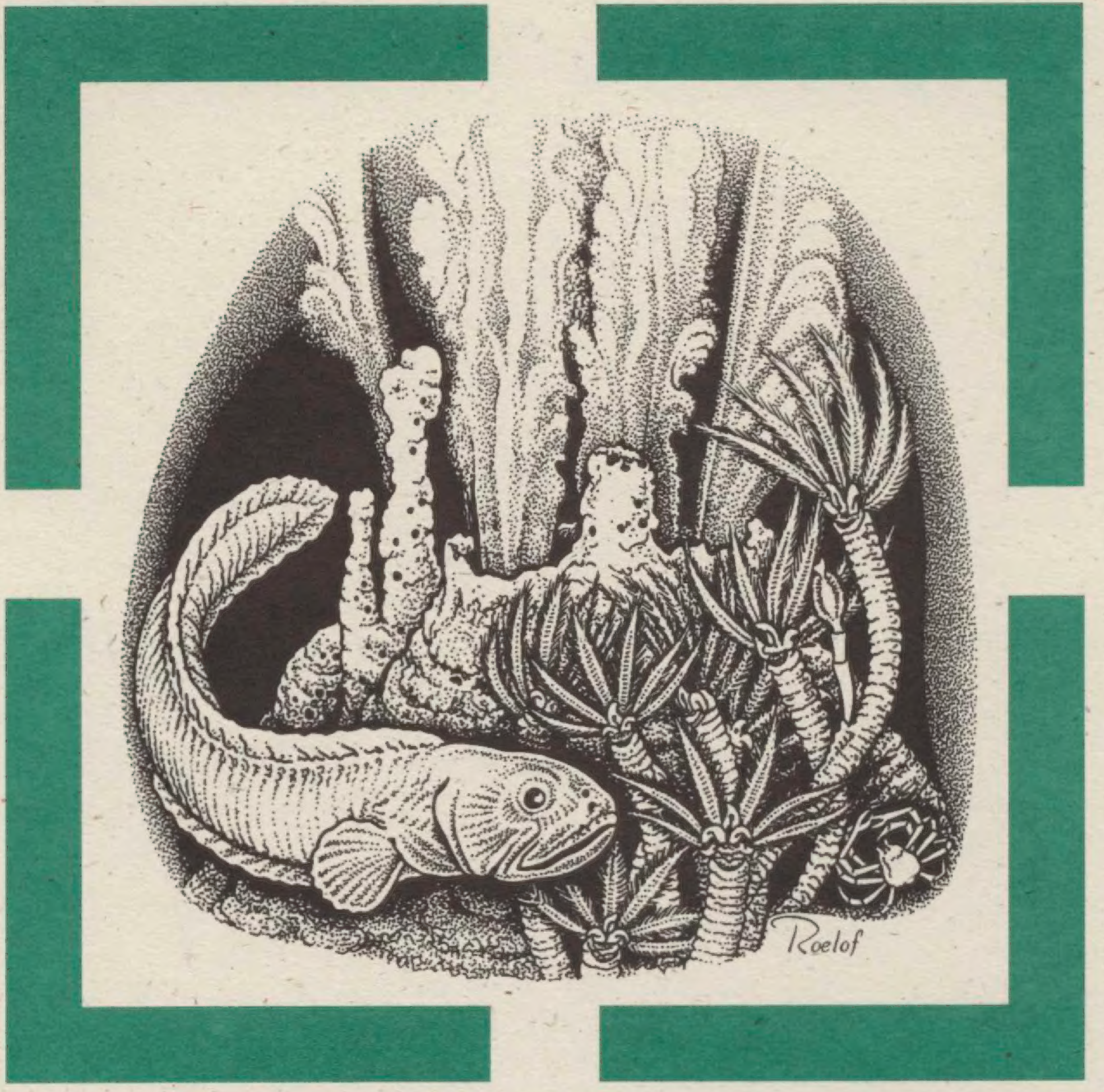

This is a typical "black smoker" with mineral chimneys that vent dark hydrothermal fluids. The adaptations of vent creatures and high densities of interdependent bacteria make it impossible for them to survive away from hot springs. The pinkish-white "Eelpout" of the *Zoarcidae* family and the whitish "Brachyuran Crab" are omnivorous and occasionally nibble on the fleshy plumes of tube worms. The worms in this drawing are a new species, *Paravinella palmiformis*.

I first became aware of conservation stories while sitting with an old friend one afternoon, discussing the plight of the St. Lawrence beluga whale. My friend, an economics professor, was arguing that conservation efforts to save the species should and would be determined according to economic value. In essence, unless the beluga, or any other species for that matter, were "worth" saving, then conservationists should turn their attention elsewhere.

Anne Bell, 1995, *Trumpeter* 12(2): 88

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